DOCUMENT RESUME

ED 238 679	SE 041 774
TITLE	Genes and Surroundings. [Student's Guide.]
INSTITUTION	Biological Sciences Curriculum Study, Colorado Springs, CO. Center for Education in Human and Medical Genetics.
SPONS AGENCY	Health Services Administration (DHHS/PHS), Rockville, MD.
REPORT NO	ISBN-0-8403-3065-0
PUB DATE	83
NOTE	150p.; For the teacher's guide, see SE 041 773. Photographs may not reproduce clearly.
AVAILABLE FROM	Kendall/Hunt Publishing Co., 2460 Kerper Blvd., Dubuque, IA 52001 ($3.95).
PUB TYPE	Guides - Classroom Use - Materials (For Learner) (051)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	Activity Units; Aging (Individuals); Biology; Discussion (Teaching Technique); Environmental Influences; *Genetics; *Heredity; *Individual Differences; Instructional Materials; Junior High Schools; Middle Schools; *Science Activities; Science Instruction; Secondary School Science
IDENTIFIERS	Chromosomes; PF Project

ABSTRACT

This activity unit on human and medical genetics for junior high and middle school students emphasizes variability and diversity in genetics. Twenty-five activities are organized into five sections: (1) individual differences among human beings; (2) causes of similarities and differences among humans and between generations; (3) variety in living things and ways in which people are alike; (4) changes caused by aging; and (5) effects of the environment on humans. Each activity includes a list of materials needed, directions for completing the activity, questions for discussion, suggestions for further exploration, and a self quiz. (DC)

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GENES AND SURROUNDINGS

The Center for Education in
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This work was developed under a grant from the Health Services Administration, Public Health Service, U.S. Department of Health and Human Services. However, the opinions expressed herein do not necessarily reflect the position or policy of the Health Services Administration, and no official endorsement should be inferred.

FOREWORD

Adolescence is a time of rapid growth and change. The transition from child to young adult is felt and expressed in numerous ways by the emerging adolescent. Physical changes, new and sometimes unsettling emotions, and changing values occur simultaneously, contributing to the struggle for a sense of identity. Always the underlying questions for the adolescent seem to be, "Am I different?" "Do I fit in?"

Human genetics is the science of human variability—its origins and its implications. At no time is that variability more evident than during adolescence, as anyone who has worked with junior high or middle school students knows quite well.

The materials that follow examine human genetics from the perspective of variability and diversity. In doing so, the activities often make use of the raw materials available in the classroom—the students. Students are asked to observe, record, and interpret the variability that surrounds them. They are asked to consider its biological roots and its ultimate expression in the myriad environments that constitute modern society.

In that sense, these materials represent a departure from more traditional approaches to genetics. This new approach has not been undertaken lightly. The activities in this program represent almost five years of analysis of human genetics education. Also, in recognition of the tremendous diversity among junior high and middle school students, the materials have been designed to accommodate a wide range of cognitive skills and social and emotional development.

The people listed as authors and project staff represent only a fraction of the people who contributed to the development of objectives and content for this program. The individuals are too numerous to catalogue here, but their expertise spans the disciplines, from medical genetics and health to educational psychology and classroom teaching and to theology and bioethics.

We are grateful to the staff of the Bureau of Maternal and Child Health, Health Services Administration, U.S. Public Health Service, and to the staff of the Division of Maternal and Child Health, Colorado State Health Department, and Georgetown University for their support of this project. Their recognition that public education and effective health care are mutually supportive will contribute significantly to progress in health promotion and disease prevention.

We hope you enjoy using these materials in the classroom as much as we enjoyed preparing them.

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SECTION I
YOU AND ME

EVERY HUMAN BEING IS DIFFERENT FROM OTHER HUMAN BEINGS.

HOW ARE YOU DIFFERENT FROM OTHER PEOPLE?

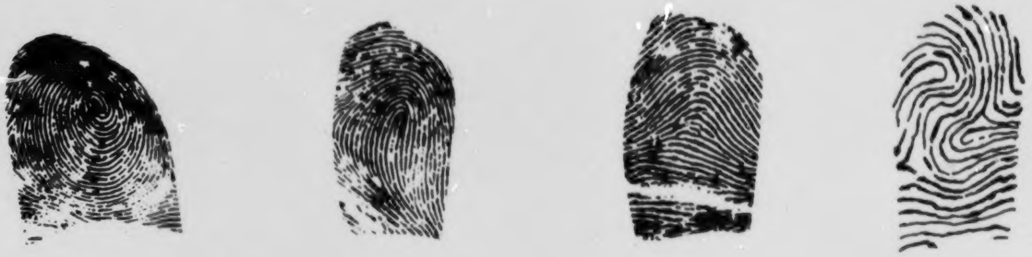
Activity 1
NO TWO ALIKE

You probably have heard it said that "no two people are exactly alike." Is that really true? You might think identical twins are exactly alike. But even identical twins turn out to be different, if only slightly. Their weights, facial expressions, their interests or talents may be different. Every difference between the twins makes each twin unique. Can you think of some other ways in which identical twins are different from one another?

Most people do not have an identical twin. But they do have parents, and they may have brothers or sisters. Relatives, even close relatives, are different in many ways. Even though blood relatives have many similar characteristics, there are always some differences. Some of these differences may be easily seen, such as hair color, shape of face, height, and shape of teeth. Other differences, such as blood type, blood pressure, or special interests may not be so easily observed. However, all differences make a person unique. And no two people have ever existed who were exactly alike. Thus, we say that each person is unique. Unique means "one of a kind." It means there is no one exactly like you.

One of the easiest ways to see differences in people is to look at their fingerprints. No two people in the world have the same fingerprints—not even identical twins. However, all fingerprints fit into one of four different patterns. Any one, or a combination of all, of these patterns may occur on the fingers of any hand.

For example, you may have more than one of these on either hand. Therefore, your fingers may have different prints.



Whorl **Loop** **Arch** **Composite**

Figure 1.

In this activity, you will have a chance to learn about fingerprints and how no two are alike.

Materials

Stamp pad or alternative fingerprint material
Index card (unlined, 5" x 8")
Magnifying glass

Directions (Part I)

1. Get the index cards from your teacher. Get enough cards for the family members you will fingerprint. Divide each index card into ten sections. Label the cards like this:

PERSON'S NAME				
Right Thumb	**Right Index**	**Right Middle**	**Right Ring**	**Right Little**
Left Thumb	**Left Index**	**Left Middle**	**Left Ring**	**Left Little**

Don't spend a lot of time making the cards. The lines and labels don't have to be perfect. You just need some way to record the fingerprints.

2. Record your own fingerprints by doing the following. Wash and dry your hands. Press each finger flat on the stamp pad or on the substitute material to color your fingers. (Don't roll the finger.) Then press it flat on the proper section of the card. You may want to practice on plain paper before you use your cards. This will help you get clear prints. After you have prints of all your fingers, wash and dry your hands again.

3. Which of the four patterns shown in Figure 1 looks most like your fingerprints? Each fingerprint will be different. The patterns of any finger will not look exactly like one of the basic patterns. But it should be close enough so you can decide. Count the total number of each pattern among your fingerprints. Record that number. Each finger should be one of these patterns.

MY FINGERPRINTS

Whorl ____________ **Arch** ____________

Loop ____________ **Composite** ____________

4. Take the stamp pad (or substitute) and cards home. Record fingerprints from your relatives.

Directions (Part II)

1. Classify the fingerprints from one of your relatives. Record the numbers of each pattern as you did for your own fingerprints.

Whorl ________ **Arch** ________

Loop ________ **Composite** ________

2. Trade your own fingerprint card with another student. Record the numbers for the other student.

Whorl ________ **Arch**

Loop ________ **Composite** ________

3. *If you wish,* you may record data for other members of your family or other students in these spaces. Indicate which are family prints and which are student prints.

Whorl	________	**Whorl**	________	**Whorl**	________
Loop	________	**Loop**	________	**Loop**	________
Arch	________	**Arch**	________	**Arch**	________
Composite	________	**Composite**	________	**Composite**	________

Questions for Discussion

Write your answers for the following questions. Discuss your answers with your classmates.

1. Look at the counts you made and at the fingerprint cards. Are your fingerprints more like your relative's or more like another student's?

   Are all your prints exactly alike?

   In what ways are they different?

2. How can fingerprints be used?

3. Explain, *in your own words,* how fingerprints show that every person is unique.

Going Further

1. Find another student who has about the same number of whorls, loops, arches, and composites as you do. Work with that student to compare your fingerprints. List the ways your fingerprints are different.
2. Try to solve a mystery using fingerprints.
   a. Obtain the fingerprints of four friends.
   b. Cover a small book with white paper.
   c. Have your four friends ink their fingers before you leave the room.
   d. While you are out of the room, *one person* should pick up the book, leaving her or his fingerprints.
   e. Come back into the room and try to figure out who picked up the book. Can you find the "guilty" one by comparing fingerprints?
3. Think of a way your fingerprints could be used as a decoration, in a design or in a unique way.

YOU ARE UNIQUE

No two people are exactly alike. Sometimes the differences can be very useful. differences can be used to identify people.

Brand new babies look very much alike. How do the people in a large hospital make sure they don't mix them up? For one thing, they put a tiny plastic bracelet on each baby. The bracelet has the parents' name on it. But what if the bracelet should come off? In many states, each birth certificate carries the baby's footprints. If it becomes necessary, the baby can be identified by its footprints.

Did you know that dogs, cats, and other animals have a very good sense of smell? It's much better than ours. Your pet has learned to recognize the sound of your voice or your whistle, and it knows what you look like. It also recognizes your unique smell.

Sometimes people are badly hurt or killed in explosions, floods, or other disasters. It may be necessary to identify these people by their unique characteristics. Doctors can check unique characteristics such as fingerprints, blood types, teeth, unusual skin markings, or bone structure. Police departments sometimes use procedures like these to solve crimes.

Will there ever be someone just like you? Probably not. The chances of two people being born who are just alike are very, very small. In fact, the chances are so small that we can safely say that no one exists who is exactly like someone else. And no one has ever existed who was exactly like someone else. For this reason, each of us is, indeed, "one of a kind."

Self Quiz

1. Draw an example of each of the four basic types of fingerprints in this space.

(WHORL) (LOOP) (ARCH) (COMPOSITE)

2. Studying fingerprints shows that
    a. a person's fingerprint patterns can change.
    b. people are different.
    c. two people can have fingerprints that are exactly the same.

Activity 2

ANOTHER YOU

If you could have designed yourself—your looks, interests, talents, and abilities—what would you be like? Would you be different? Here is a chance to plan a different you. How will your ideas compare with those of others in the class?

WOW! IT'S ME!

I want to be like someone else.
I can't stand the way I look.
I want to be a movie-star.
Or write a famous book.
My hair is too long.
My nails are too small.
I weigh too much, or not enough.
And I'm definitely too tall!
I want to jump like "Magic."
Or dunk em' like "Dr. J."
"Look how big and mighty,"
All the people would say.
I want to be the President.
And run the U.S.A.!
I'd solve all the problems,
Each and every day!
I guess my hair is okay,
And Magic's *much* too tall.
No! I don't have to be like you
'Cause I'm the best of all!!

Char Roehm
Dunstan Junior High School
Denver, Colorado
1980

Materials

6 paper squares (2 cm on each side)
Sheet of graph paper
Ruler

Directions

1. Read over the characteristics and choices in the Another You Questionnaire on page 9. For each category, make *one* choice. Circle your choice for each characteristic. Do not discuss your choices with other students.

2. Make six paper squares. The sides should each be 2 cm long. On one of the paper squares, write the number of a characteristic and the letter of your choice (for example, 1D). Fill out the six squares, one for each choice. Then put each square in the correct collecting box provided by your teacher.

3. While the choices are being counted, draw bar graphs on your graph paper. To do this,

   a. Fold your graph paper into thirds. Use both sides of the paper; this will give you space for six graphs.

   b. Use your ruler to draw a horizontal line and a vertical line that meet near the lower left-hand corner. Do this in each of the six sections of your graph paper.

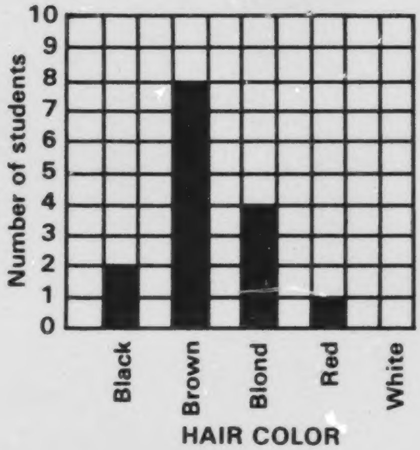


Figure 2.

   c. Figure 2 is an example of one of the graphs—the graph for hair color. Use the figure as a guide for labeling your six graphs. Label the graphs with "Number of Students" on the left side. Just below the line across the bottom of each graph write the five variations of one of the characteristics.

4. As the totals are announced, mark the top of the bars on each bar graph. Your teacher will show you how to do this. Then, color all of the bars on your graphs.

ANOTHER YOU QUESTIONNAIRE

Circle *one* choice for each characteristic. Choose the one that best fits your plan for another you today.

1 HAIR COLOR	A black	B brown	C blond	D red	E white
2 EYE COLOR	A blue	B brown	C hazel	D black	E green
3 SKIN COLOR	A very light	B light	C medium	D dark	E very dark
4 HEIGHT	A under 5′	B 5′ to 5′5″	C 5′6″ to 5′8″	D 5′9″ to 6′	E over 6′
5 WEIGHT	A under 100 lbs.	B 100 to 120 lbs.	C 121 to 150 lbs.	D 151 to 200 lbs.	E over 200 lbs.
6 INTELLIGENCE	A genius	B above average	C average	D below average	E dull

Questions for Discussion

Write your answers to the following questions. Discuss your answers with the class.

1. Did everyone in the class make the same choices?
2. Would your choice have been different if you were planning an adult "you"?
3. Would your choices have been different if you lived somewhere else? For example, which characteristics would you have picked if you lived in the desert?
4. Name a personal characteristic you think you could control permanently or change. Name one you cannot control.
5. Do you think you could ever become that other person you made up? Why or why not?

Going Further

1. Radio and television producers and magazine publishers sometimes are accused of showing only "perfect" people. Conduct a survey of television shows or magazines to see if you think this charge is true.
2. Write a story about a person who was able to change some physical characteristic that he or she did not like. For example, you could tell about a person who lost weight, or changed hair color, or had plastic surgery.
3. Think about how the way you live relates to the different characteristics you chose. Do you think the way you live had anything to do with the choices you made? Or do the things you prefer determine the way you live?

Self Quiz

1. What do you think influenced your choices of characteristics in this activity?

Activity 3

SOMETHING OF VALUE

How many times have you wished that you could be like someone else? Have you also had times when you were glad that you were you? Did someone ever say to you, "I wish I could be like you"?

In this activity, you can think about your special talents. You may be able to sing, draw, dance, or be a special friend. You can think about how those special talents make you able to help others.

Materials

Mystery clues

Directions (Part I)

1. Think about talents that make you different from other people. What can you do very well? Maybe you can draw, or sing. Maybe you have the ability to be a special friend. List some of your talents.

2. Think about the special talents that people in your class have. List some of these talents. Be sure to include your own talents in this list.

Questions for Discussion I

Write your answers to the following questions. Discuss your answers with other students.

1. How do other people's talents help you?

2. How do your talents help other people?

Directions (Part II)

In this part of the activity, you and your classmates will work together. Each of you will have information that is needed to solve a mystery. Your teacher will give you the clues and will help you solve the mystery.

THE MYSTERY IS: What Is Ann's Class Schedule?

1. Work in small groups. (A small class may work as one group.)
2. Get the clues from your teacher. (If your group is quite small, each of you may have more than one clue.)
3. Do not show your clue, or clues, to anyone else or give it to anyone else.
4. Stay in your seat and communicate only by talking.
5. Let the other group members know about your clue by reading it to them.
6. Your teacher will talk to only one person from your group and will answer only one question at a time. Ask your teacher only "yes-no" questions about the directions.
7. As a group, decide how you can use your clues to solve the mystery of Ann's class schedule.
8. Check your answer with the teacher when you think you have solved the mystery.
9. If you make a mistake in your answer to Ann's schedule, try again.

Ann's classes are: Art, English, History, Lunch, Math, Physical Education, Science

	CLASS PERIOD						
	1	2	3	4	5	6	7
ANN							
MARK							
SUE							
JEFF							
DAN							
RITA							

Questions for Discussion II

After your class has solved the mystery, discuss the following questions.

1. Each person in your group had "something special" that was needed to solve the mystery. What did each person have?
2. How were the clues in this mystery like the talents in your class?
3. What talents, other than your clues, did you use in solving this mystery?

Going Further

1. Read a story about a famous person and list the special talents that enabled that person to become famous. Choose your own story or ask your teacher to provide a story for you.
2. Ask your teacher for another "mystery" to solve. Follow the same rules as you did for the first part of the activity.

Self Quiz

1. List three benefits of people having different talents.

Activity 4

WHAT DOES IT TAKE?

What does it take to be good at something? Different people are good at different things. One person may be good at music, art, or auto mechanics (or maybe all three). Another may be skilled at typing, running, reading, math, or carpentry.

Talents often go hand-in-hand with interests. A person who likes to collect stamps may become an expert in geography and languages. A person who likes music may become very good at dancing, singing, or playing a musical instrument.

Our bodies, minds, and environments may influence the talents we develop. There are many ways to think about this. In this activity, we will use three categories:

The first is *physical,* something about our bodies. Long legs may help a runner. Nimble fingers may be important to a piano player.

The second is *personal* or *personality.* Some people like to spend many hours practicing a musical instrument. These people may develop their talent to the fullest because they are patient and hardworking. A person who likes to talk and listen to others may become more skilled at politics than poetry.

The third category is *environmental.* Environment includes our physical surroundings and the people around us. People who live near the Rocky Mountains in Colorado have more chances to ski than do those who live in Georgia. They may become better skiers simply because it is easier for them to practice. People also affect what we can do. A teacher may help students improve their skills in reading, writing, or math.

In this activity, you will have a chance to think about how physical, personal, and environmental characteristics influence talents. You will explore the question, "What does it take to have a talent?"

Directions (Part I)

1. Listen to your teacher read a story about Manuel Ortiz. The story is printed on pages 15 and 16, so you can follow along if you wish.
2. As your teacher reads, try to pick out some of the things that help make Manuel a good swimmer. Take notes as you listen. Write your notes in these columns:

PHYSICAL	PERSONAL	ENVIRONMENTAL

3. After you've read the story and made notes, your teacher will ask several students to share their ideas with the class. List these ideas on the chalkboard. Copy the lists from the chalkboard here:

PHYSICAL	PERSONAL	ENVIRONMENTAL

MANUEL

Manuel Ortiz is 13 years old. He lives with his mother and his older sister in a comfortable, second-floor apartment in San Francisco. He is a seventh grader at Golden Gate Middle School. His favorite subjects are math and art. He tries, but he finds it hard to like geography.

Manuel loves to read mystery stories, go to the beach with his friends, and take pictures. But right now, there is one special interest that takes up most of Manuel's time.

Manuel is a champion swimmer. His best event is the 100-meter free style, and he is always the anchor in the 100-meter relay with his school swim team. Manuel has placed first in school, city, county, and state competitions. His coach believs that Manuel has a good chance of qualifying for the next Olympic swim team. Now, Manuel spends most of his free time practicing and working with his coach to improve his speed and form.

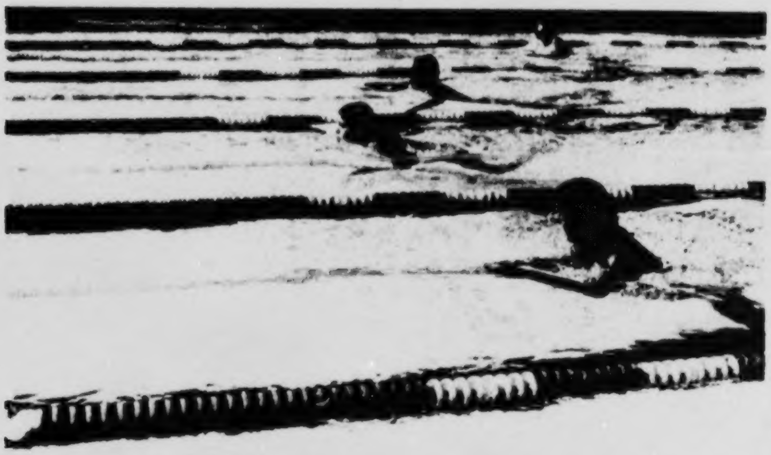
How did Manuel get to be such a good swimmer? He recalls learning to swim when he was very young. He and his sister spent many afternoons at the YMCA. They took swimming classes and had fun during the "free swim" period whenever they could.

Sometimes Manuel's Aunt Anita would go with them. When Manuel was only three or four, Anita used to say, "What a natural swimmer Manuel is. He jumps right in, kicking and swinging his arms with so much joy. He is strong, lean, and tall for his age. He can hold his breath under water for the longest time. He can swim for hours and never seems to get tired. And he loves the water."

Manuel loved the water when he was a young boy and he loves it now. His swimming is still a lot of fun, but it is also a lot of hard work. Manuel says that when he was seven, he started to work in advanced classes. The coach wanted to help him become a champion swimmer.

"My coach had a dream," Manuel says. "He had been looking for someone like me for a long time. When I came along, he asked my mother and me whether I wanted to work really hard at my swimming. I decided then that I wanted to give it a try and I have been working hard at it ever since.

"Oh, sometimes I feel tired or discouraged, or I wish that I could do something else besides go to the pool every day. But usually, I just forget about doing anything else and go to the pool and work as hard as I can. I started this six years ago, and I'm not about to give up on it now."



There are many things that Manuel does to improve his swimming. He does special breathing exercises to make his lungs stronger. He is very careful about what he eats. His coach and the dietitian at school helped him work out a plan for well-balanced, nutritious meals. No sugar donuts and chocolate chip cookies for Manuel!

What's more, he takes a dancing class once a week to improve his rhythm and sense of timing. He thinks the fast dances make him more flexible and agile. Sometimes, he lifts weights to develop strength and muscle tone.

Manuel thinks he is lucky to live close enough to go to Golden Gate Middle School. Most of the other middle schools and junior high schools in the area do not have swim teams. Manuel has had many chances to improve his swimming in the city pool his school uses for classes and competitions. He doubts he would ever have become a champion swimmer if he had not been able to compete in so many swim meets.

"You just don't know how to handle competition until you do it many times," Manuel says. "I was scared at first, and I still get scared before a meet. But it is not as bad as it used to be. Having other people there from my own school helps a lot."

What do Manuel's mother and sister think about all this? They are happy and proud, but they wish Manuel were home more. The cost of lessons and travel sometimes strains the family budget. But they do their best to encourage Manuel to be as good as he can be. And they are there, cheering him on, each time Manuel competes.

Questions for Discussion I

Write your answers to the following questions. Discuss your answers with your classmates.

1. From what you have learned about Manuel, what do you think it "takes" to be a champion swimmer?

2. Which characteristic do you think is most important?

3. Suppose Manuel had chosen baseball, instead of swimming, as his favorite sport. Which of the things you and your class listed would be more important for baseball than for swimming?

   Which would be less important?

7

Directions (Part II)

Rewrite Manuel's story. Manuel is the same person but his environment has changed. He is still a good athlete. He enjoys math and art and lives with his mother and sister. Manuel goes to a school that has no swim team. His city pool has been closed for several summers. His coach is interested in track. Write a story about Manuel in this environment.

Answer the following questions using your story.

1. What talent did Manuel develop?

2. Complete a chart to show what influenced Manuel's talent.

MANUEL'S TALENT ______________________________

PHYSICAL	PERSONAL	ENVIRONMENTAL

3. How were Manuel's interests and talents affected by the change in his environment?

Going Further

Read a story or book about a famous person who had a special talent. What factors affected this person's talent? Some books on famous people can be found under autobiographies and biographies. Ask your librarian to help you find books that are interesting and easy to read.

Self Quiz

1. Characteristics are determined by
   a. heredity
   b. environment.
   c. both heredity and environment.
2. Show your story from Part II to your teacher. You might want to read it to your classmates. Discuss how Manuel's talents were affected by his changed environment.

SECTION II
GENERATIONS

ALL PEOPLE HAVE THE SAME NUMBER OF LEGS, EARS, NOSES, AND SO ON.

BUT PEOPLE ARE DIFFERENT IN SIZE, SHAPE, COLOR, AND OTHER CHARACTERISTICS.

WHAT CAUSES
THE SIMILARITIES?
WHAT CAUSES
THE DIFFERENCES?

Activity 5
GENERATIONS

Generations: steps in a line of descent; for example, parents are one generation, and their children are the next generation.

Genes: the units of inheritance that pass from one generation to the next. Genes determine such characteristics as eye color, hair color, and blood type.

We all know that parents and their children are alike in some ways. Perhaps someone has said to you, "You look just like your mother" or "You have your grandfather's eyes." There are many ways that we are like our parents and our grandparents. There also are, of course, many ways that we are different. What are some of the reasons for these likenesses and differences?

Every cell in a person's body contains something called "genes." Genes are too small to be seen, but they are the "blueprint" that determines many things about you. Genes control the color of your hair. They also have a lot to do with how tall you are, how heavy you may become, and how big your feet will get.

In this activity, you will have a chance to show how something is passed from grandparents to parents to children.

Materials

(per student or team)

24 jelly beans
  (6 red, 6 green, 6 yellow, and 6 blue)

6 paper cups

felt marking pen, black

felt marking pens,
  in colors that match the jelly beans

Directions

1. Label the six paper cups as follows:

   Grandfather 1
   Grandmother 1

   Grandfather 2
   Grandmother 2

   Father
   Mother

   Place the cups on the table in an arrangement like that shown on page 23.

2. Place 6 red beans in the Grandfather 1 cup and 6 green beans in the Grandmother 1 cup. Put 6 yellow beans in the Grandfather 2 cup and 6 blue beans in the Grandmother 2 cup. The beans stand for the genes of each of the grandparents—those "somethings" that the grandparents will pass on to their children. Color the diagram on page 23 to show the colors used for each grandparent.

3. Without looking, select three beans (genes) from the Grandfather 1 cup and three from the Grandmother 1 cup. These genes represent the daughter of the first grandparents—the daughter who will grow up to become a mother herself. Place them in the cup marked Mother. The Mother now has six genes, just as did each of her parents.

4. Without looking, take three genes each from the Grandfather 2 and Grandmother 2 cups. Place them in the cup marked Father. The Father should now have six genes, just as did each of his parents. Color the diagram to show the genes for the Mother and the Father.

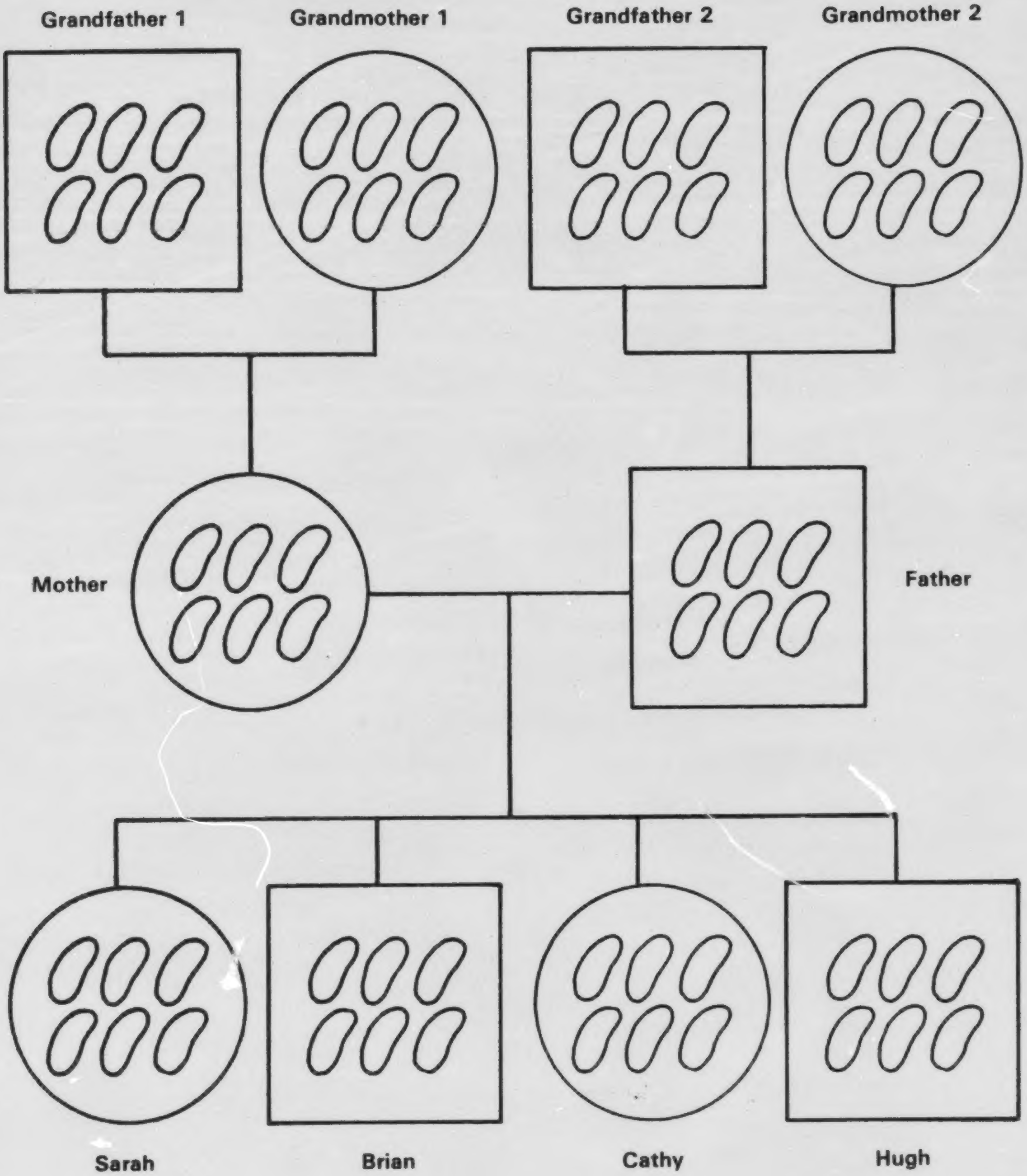
5. Assume that the Mother and Father have four children—Sarah, Brian, Cathy, and Hugh—as shown in the diagram. To find Sarah's genes, draw (without looking) three genes each from the Mother and Father cups. Color the blanks in the space for Sarah to match the colors of the genes you chose.

6. Return all genes to the cups. (Return red and green genes to the cup labeled Mother. Put the yellow and blue genes in the cup marked Father.) Now select Brian's genes. Close your eyes when you select the genes.

7. Summarize your data in the following table. In each box, write the number of genes each child received from each *grandparent*. (The total should always be 6.)

	Sarah	**Brian**	**Cathy**	**Hugh**
Grandfather 1 (red)				
Grandmother 1 (green)				
Grandfather 2 (yellow)				
Grandmother 2 (blue)				
Total	6	6	6	6

GENERATIONS


Grandfather 1
Grandmother 1
Grandfather 2
Grandmother 2
Mother
Father
Sarah
Brian
Cathy
Hugh

Questions for Discussion

Discuss the following questions with other students. Record your answers in the space provided.

1. Were any of the four children exactly alike?

   If your answer was yes, what do you think would have happened if you had been working with many hundreds of genes, instead of only six?

   If your answer was no, why do you think it turned out that way?

2. Why was it necessary to take three genes from the Mother cup and three from the Father cup to make the total of six genes in each child?

3. Why was it necessary to return the genes to the cup each time?

4. Suppose the beans actually were genes that controlled some very obvious characteristic. Which of the children would look most alike?

   Why?

   Which of the children would most resemble a parent or grandparent?

   Why?

Going Further

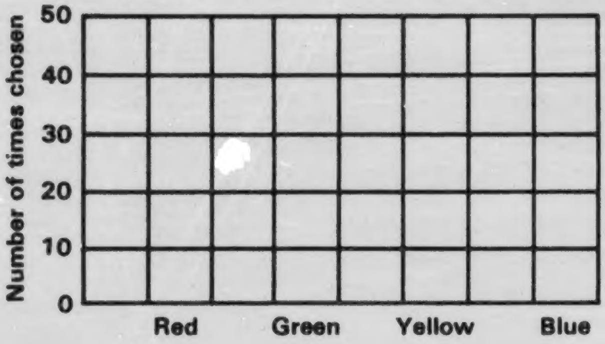
Part I

1. Repeat the process described in Steps 5 and 6 of the Directions 20 times. Record the colors of the beans selected each time on this tally list.

COLOR	TALLY
Red	
Green	
Yellow	
Blue	

Then complete the bar graph.

What do you notice about the heights of the bars?



2. Complete the following statement by circling the letter for each of the endings that would result in a true statement. *The chance that a red bean will be selected is...*

   a. *about one in four.*

   b. *about 30 out of 120.*

   c. *about the same as the chance that a yellow bean will be selected.*

   d. *about the same as the chance for any other bean.*

   Give reasons for your answer.

3. Do you think your results would have been the same if you had started out with twice as many red beans as any other color?

   Why or why not?

Part II

Read "From One Generation to Another" on the following pages. Then answer the Questions for Discussion.

FROM ONE GENERATION TO ANOTHER*

About a hundred years ago, it was discovered that every person begins as a separate bit of living matter produced by his or her parents. This bit, the fertilized egg, contains all the information necessary for the development of a complete human body. A new person always comes from people who have existed before. In this way, life continually renews itself by making new individuals.

Behind you and me in history, then, were many individuals. Those people died. But they live on in us, just as we will live on in our children and our grandchildren. When viewed in this way, a living thing is not temporary. Rather, a living thing carries an information system—genes—that links that person back to past generations. Being alive is the result of inheritance. And genes are the units of inheritance.

The Fertilized Egg

The fertilized egg results from the union of two separate bits of living material: the sperm produced by a man and the egg produced by a woman. Near the center of the fertilized egg is an area called the *nucleus* (NEW klee us). The nucleus contains the genes. The genes actually are part of structures called *chromosomes* (KRO muh sohms). The genes determine inheritance. An entire modern science—genetics—is built around the study of genes and chromosomes.

Egg, Sperm, and Heredity

Many people associate the word egg with a chicken, or perhaps with other visible eggs, like those of fish or aquarium snails. But size isn't really all that important. Basically, eggs are alike whether they are very large, like chicken eggs, or too small to be seen without a microscope, like the eggs of dogs, cats, and people.

For many living things—chickens, fish, snails, dogs, cats, and people, for example—the egg alone is not enough to start a new individual. Fertilization by a sperm must happen first. An egg is fertilized when the egg and sperm unite (join together). When they unite, the genetic information—the genes—also unite. Thus, the new individual gets half of its genes from the mother and half from the father.

---

*Adapted from Hampton L. Carson, *Heredity and Human Life,* Columbia University Press, New York, 1963.

The Puzzle of Inheritance

It is correct to say that "like produces like"—but not *exactly* alike. Consider the following example. Your pet female cat may have kittens. When the kittens are born, it will be easy to see the first basic fact of heredity. The fertilized eggs have produced *only kittens.*

But the second fact about heredity may not be so obvious. None of the kittens will be exactly the same as its mother. And no two kittens will be exactly alike. Each kitten receives one-half its genes from its mother and one-half from its father. Each kitten receives its own set of genes. Therefore, no two will be exactly alike.

Suppose the mother is a tortoise-shell tabby. This means she has yellow spots on a gray-striped background. Some of her kittens may be all black or all yellow. Some may be a very light, washed-out blue (maltese). In others, there may be areas of white that do not appear on the mother.

Some of the female kittens may be tortoise-shell tabbies like their mother. But their yellow spots very probably will not be in the same places or of the same size. Like has produced like, but the likeness does not result in exact copies.

Here is the puzzle for the student of heredity: How are general similarities ("catness," in our example) carried from one generation to the next, while differences also arise?

Questions for Discussion

1. How would you answer the puzzle of "alike, but different" from what you did in the first part of this activity?

2. Write a paragraph about some other examples of "alike, but different." You might want to write about dogs, horses, fish, frogs, or people. Discuss your paragraph with other students.

Self Quiz

1. What is a gene? Where is a gene located?

2. Where do the genes come from that make up a new individual?

3. What is a generation?

4. Suppose you saw a field with ten brown horses in it. Would all the horses be exactly alike? Why or why not?

Activity 6

FAMILY TREES AND CHARACTERISTICS

A pedigree is a family tree that shows the relationships among family members. It is a "shorthand" way to represent the members of a family. Animal breeders often use pedigree charts to show the ancestry of their animals. Human pedigree charts may be helpful in showing an interesting family characteristic. Doctors sometimes use pedigree charts. They use the charts to see how a particular condition is passed from one generation to another.

By following a few guidelines, you can make a pedigree chart for your family. You might even be able to find a pattern in the way a family characteristic is inherited.

Materials

Drawing paper
Ruler
Circle pattern (a nickel)
Square pattern (draw a square, 2 cm on each side,
on cardboard; cut it out and use it for your pattern)

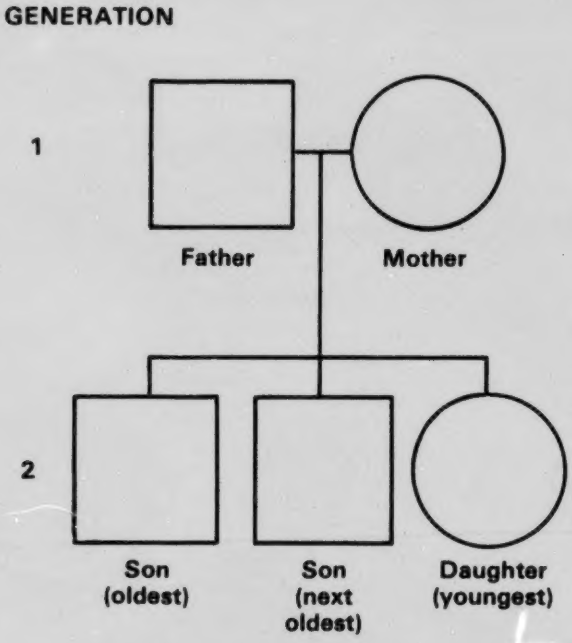
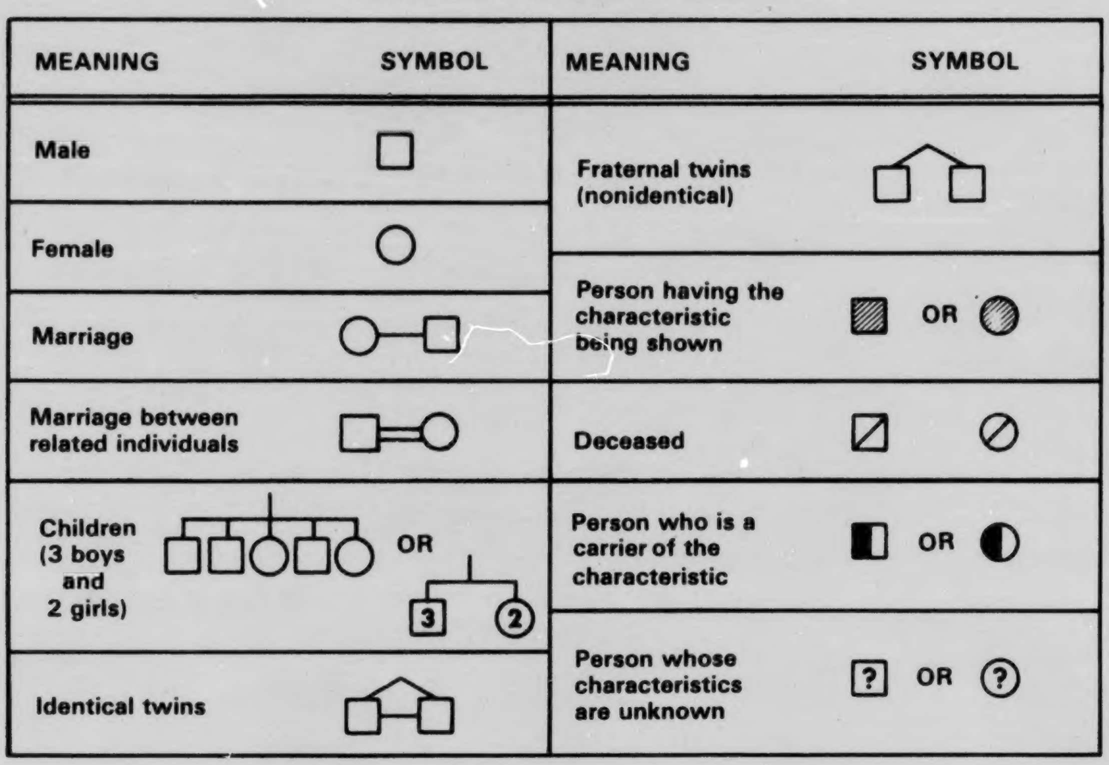


Figure 3.

Directions

1. Look at the sample pedigree chart in Figure 3. It shows a single family. What members of this family are shown?
2. All pedigree charts use the same symbols. Examine the chart in Figure 4 on page 30. Use the chart to complete directions 3 and 4.

STANDARD PEDIGREE SYMBOLS



MEANING	SYMBOL	MEANING	SYMBOL
Male	□	Fraternal twins (nonidentical)	□ □
Female	○	Person having the characteristic being shown	▨ OR ▨
Marriage	○—□	Deceased	⧄ ⊘
Marriage between related individuals	□═○	Person who is a carrier of the characteristic	◧ OR ◐
Children (3 boys and 2 girls)	□□○□○ OR 3 2	Person whose characteristics are unknown	? OR ?
Identical twins	□—□		

Figure 4. Standard pedigree symbols

3. On a separate sheet of paper, draw a pedigree chart showing a man and a woman with one son. The son is married and has four daughters. Compare your results with those of other students.
4. Read "Steven's Family Tree," on pages 31 and 32. Then, plan a pedigree chart for Steven's family. Show each generation in a separate row. Shade in the symbols for people who have the characteristic.

Questions for Discussion

1. Does there seem to be a pattern of inheritance for the characteristics? Does it appear in each generation? Is it expressed in males and females?
2. A pedigree chart shows that some characteristic is being inherited. What units of inheritance are involved? How do you think this happens?

STEVEN'S FAMILY TREE

My name is Steven Thacker. I'd like to tell about an experience I had that taught me some important lessons about genetics. For years, my dad, John Thacker, told me stories about his family—his father and mother, his two sisters, and his three brothers. Our family moved from his home town in Ohio to California when I was only a year old, so I never really knew the people he was talking about. His stories made me very curious about all my relatives that I had never seen.

Last summer, I got a chance to satisfy my curiosity. The Thacker family decided to have a family reunion on the Fourth of July in the old home town of Cos Cob, Ohio. Dad could hardly wait to get back and see his family again for the first time in 15 years. My mother, Marie, is from the same town, and she was eager to see her own family as well as my dad's. My 12-year-old twin sisters, Laura and Mary Jo, and my 8-year-old brother, Tom, also had heard a lot about the people in Cos Cob. They were delighted at the thought of a trip to Ohio.

We decided to make a real vacation out of our trip to the reunion. We drove at a leisurely pace, sight-seeing and camping along the way. We did so much sight-seeing that, on the morning of July 3, we realized we were still 700 miles from Cos Cob. The reunion was to begin the next morning at 10 o'clock. Dad said we would have to drive straight through and get a good night of sleep so we would be ready to meet all our relatives and enjoy the reunion. It was a long, 14-hour-drive. We got into Cos Cob about 9 o'clock on the evening of the third. Everybody was so tired we decided to get motel rooms and go right to bed.

In spite of all the travel and excitement, I slept pretty well and so did Tom and the twins. In the morning, after we got dressed, we had a late breakfast. Then we set out for Grandpa and Grandma Thacker's house on Pine Street. We got there at exactly 10 o'clock and were amazed to find that we were the last of the Thacker clan to arrive at the reunion. For about 15 minutes, there was a lot of hugging and kissing and squealing. I was introduced to all those aunts, uncles, and cousins I had heard about but had never met. But I have to admit that I didn't get all the names and faces straight.

After the turmoil of the initial greetings was over I was able to step back and take a better look at my relatives. It was obvious that we all are members of the same family. My dad's brother and sister were easy to spot because they look so much like him. My grandparents are older copies of their sons and daughters. The third generation—my sisters, my brother, all our cousins, and I—are alike in many ways. At the same time, each of us has special traits that make us different. I remembered one of the big lessons I learned in biology last year. The set of chromosomes we inherit, half from our mothers and the other half from our fathers, interacting with our environment, is responsible for the similarities and the differences that I was observing.

Then I noticed Grandpa Thacker's hands. I thought my dad was joking when he said that Grandpa Thacker has two little fingers on each hand. But, sure enough, it's true. I then looked at Aunt Shirley, Uncle Pat, and Uncle Dave. Again, Dad was right! They too have extra little fingers. Aunt Shirley's daughter, Sue, does not have the extra digits. But one of Uncle Pat's three daughters, Maureen, and his only son, Mike, have the extra fingers. Uncle Dave's boy, Dan, does not have the extra digits, but his girl, Karen, does. Dad's sister, Betty, and her son, Jim do not have the sixth fingers. His other brother, Gary, and Gary's two daughters, Patty and Barbara, also do not have the sixth fingers. Nobody in my immediate family has the variation.

After my initial observation of this variation in our family, I promptly forgot about it. I spent the rest of the day meeting, talking, and playing volleyball with my grandparents, my five aunts and uncles, my ten cousins, and, of course, my own immediate family. The big event of the day was a sit-down dinner that evening. We ate one of the best meals I have ever had. Many stories were told, and every one of the 28 members of the family was included in the stories at least once. Before we knew it, it was nearly midnight and time for the reunion to end.

We said "good night" to everyone and went back to our motel, where we talked for another hour or so. We spent two more days in Cos Cob visiting my parents' old friends, and my mother's family. We also did some fishing and picnicking in the country around Cos Cob.

It wasn't until we were back in California that I remembered the variation I had observed in my grandpa, my aunt, two uncles, and three cousins. I knew this had to be a genetic characteristic, but I was curious to find out more about it. In my biology class, I had learned that one of the first things you should do to learn about a trait is to make a family history and trace the characteristic through the family. I remembered that you use a square to stand for a man, and a circle to represent a woman. You shade in the squares or circles that represent people who have the characteristic (in this case, an extra little finger). With that little background, a family history (pedigree) can be constructed.

Going Further

1. Several famous pedigree charts have been used to show patterns of inheritance. Use a resource book, such as a biology or genetics book. Find the pedigree showing how hemophilia was transmitted from Queen Victoria throughout the royal families of Europe. Other famous pedigree charts show the Hapsburg lip in European nobles and the dwarfism of Tom Thumb.
2. Use the following information to construct a pedigree. Use the symbols in the chart in Figure 4. Kathleen (age 32) and Kenneth (31) are married. Kathleen's mother, Betty (60), and Kenneth's father, Ed (63), are the children of Theodore and Agnes, both deceased. Theodore and Agnes had two other children, Dorothy (65) and James (58). Betty's husband is named Randy (61); Ed's wife, Jennifer, died at the age of 59. Kenneth has a 34-year-old sister, Marjorie. Kathleen has a 27-year-old sister, Judy. Kathleen and Kenneth have three children: Fay (8); Kerry (6); and Darrell (3). Are Kathleen and Kenneth related? If so, how?

Self Quiz

1. A pedigree chart is used to (check one)

   _____ a. predict what sex a child will be.

   _____ b. show some genes that family members have in common.

   _____ c. show *all* the characteristics that are caused by genes.

2. Which of the following people probably would use a pedigree chart as part of their work?

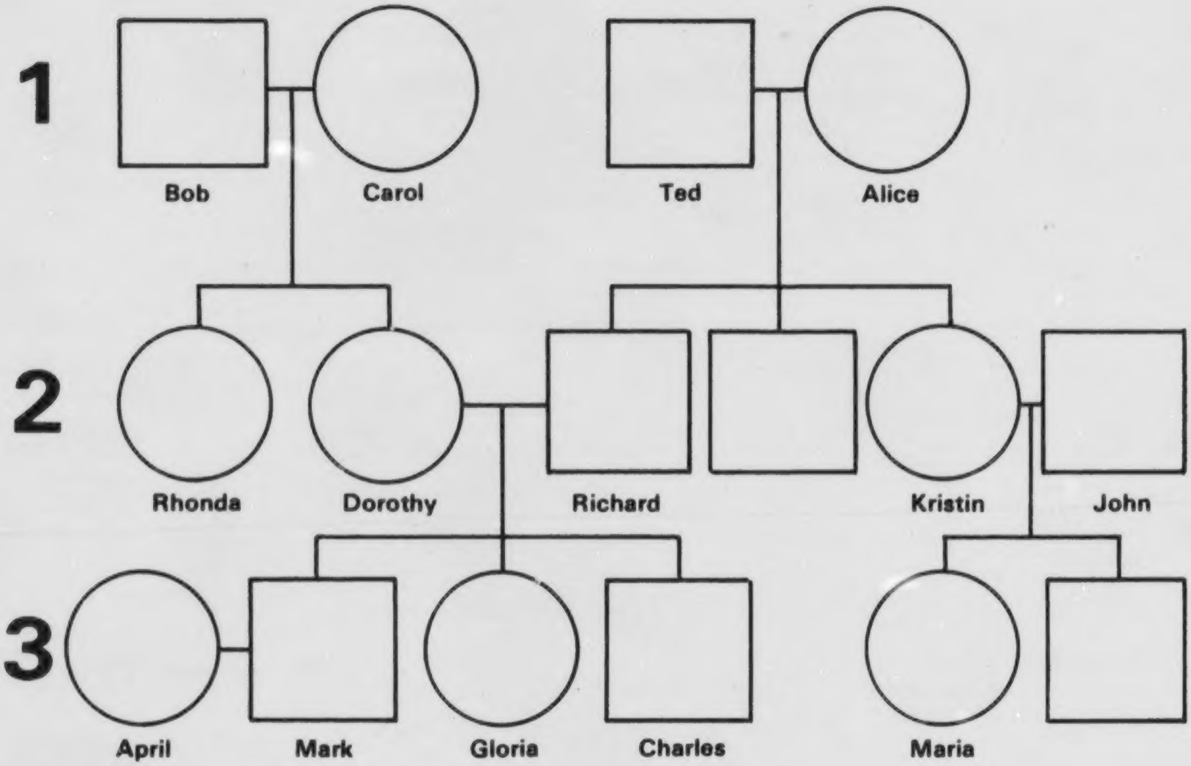
   _____ a. architects

   _____ b. engineers

   _____ c. animal breeders

3. Who might use a pedigree chart showing the members of your family? In what situations would this be useful?

4. Use the pedigree chart below to answer the following questions.
   a. How is Gloria (Generation 3) related to Carol (Generation 1)?
   b. How is Carol (Generation 1) related to Ted (Generation 1)?
   c. How are Richard and Kristin (Generation 2) related?
   d. How many children do Ted and Alice have?
   e. How are Dorothy (Generation 2) and Bob (Generation 1) related?
   f. How are Maria and Charles (Generation 3) related?


1
Bob
Carol
Ted
Alice
2
Rhonda
Dorothy
Richard
Kristin
John
3
April
Mark
Gloria
Charles
Maria

Activity 7
A CHROMOSOME IS...

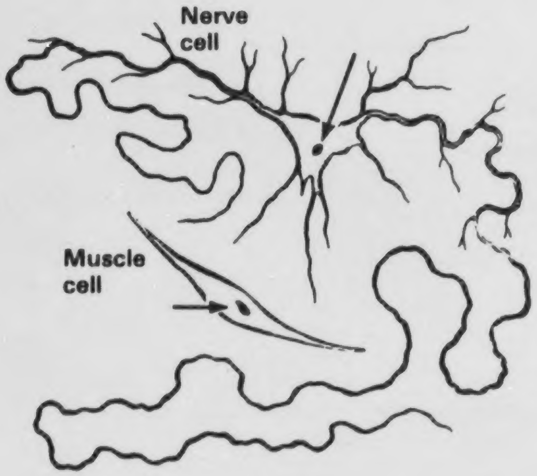
Chromosome: a structure in the nucleus of a cell. Genes, the units of inheritance, are located on chromosomes.

Karyotype: a picture of chromosomes, arranged in a standard pattern.

The word "chromosome" has been in the news a lot lately. What are chromosomes? What do they look like? Where are they located?

Cells

Your body is made up of many millions of cells. The cells are too small for you to see without a microscope. But every part of you is made up of cells. It takes many different kinds of cells to make a person—skin cells, muscle cells, nerve cells, and blood cells. The cells are of different sizes and different shapes, but they are all cells.

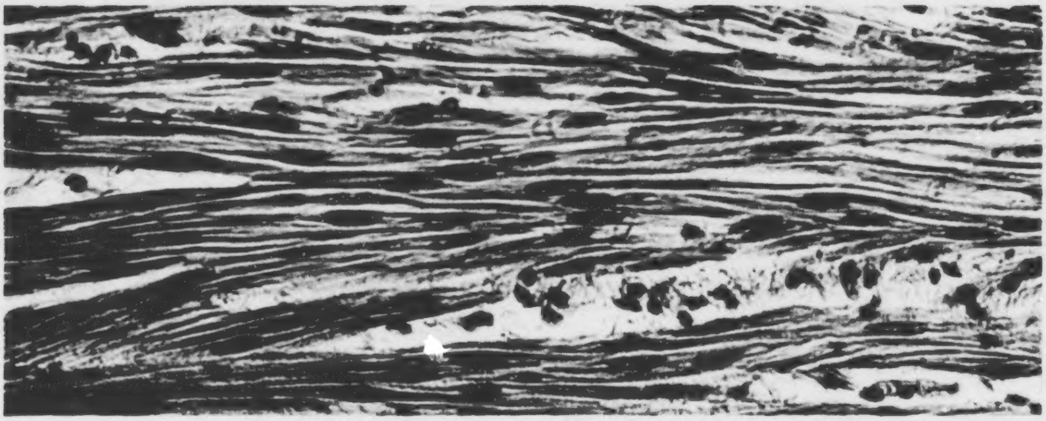


The arrows point to the nucleus in the cells.

Chromosomes Are in Cells

With only a few exceptions, every cell in your body contains chromosomes. The exceptions are red blood cells and the cells in the lens of the eye. Chromosomes are found in a structure inside the cell called the *nucleus* (NEW klee us). Genes, the units of inheritance, are parts of the chromosomes.

The skin is made up of cells. And each of these cells contains chromosomes. Chromosomes are located in the nucleus of a skin cell. If we take a closer look at muscle, we find that it, too, is made up of cells. These cells look different from skin cells. But they, too, contain chromosomes. The chromosomes in muscle cells are just like the ones in skin cells.



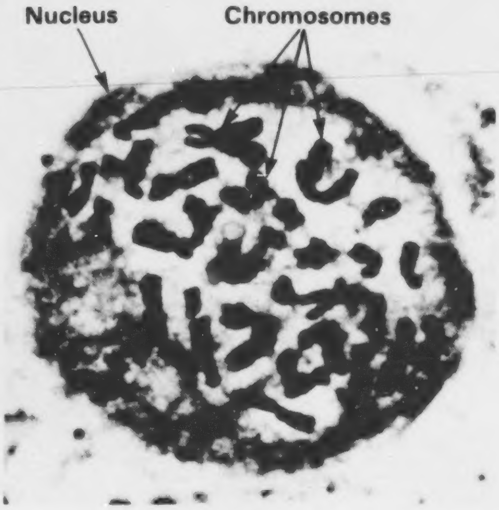
Muscle cells

Each of the body organs also is made up of cells. For instance, if you take a closer look at the cells of the intestine, you'll find that each cell contains a nucleus with chromosomes.

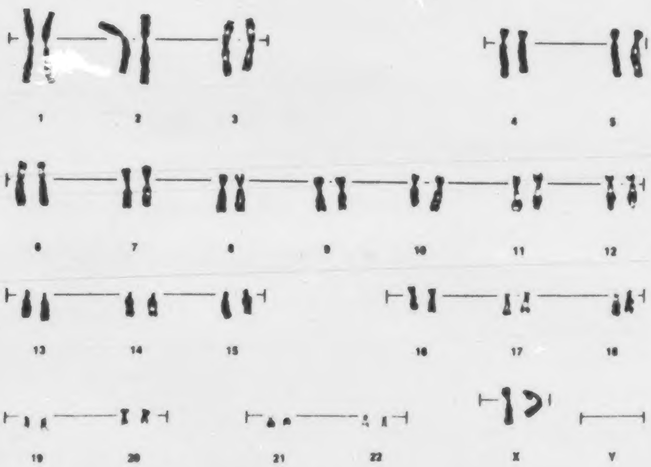
When you look closely at the cells of the heart, you find that each cell has chromosomes in its nucleus.

Scientists who study chromosomes take pictures of them through very powerful microscopes. They can do this only during a certain time in the process of cell division. During cell division, the chromosomes become tightly packed and can then be seen easily under the microscope. The scientists pick out a single cell and photograph its nucleus and chromosomes. Then they cut up the picture and arrange the chromosomes so they can study them. These rearranged pictures of chromosomes are called karyotypes.

In this activity, you will have a chance to take a closer look at chromosomes.



Nucleus with chromosomes



A karyotype

HOW SCIENTISTS MAKE KARYOTYPES

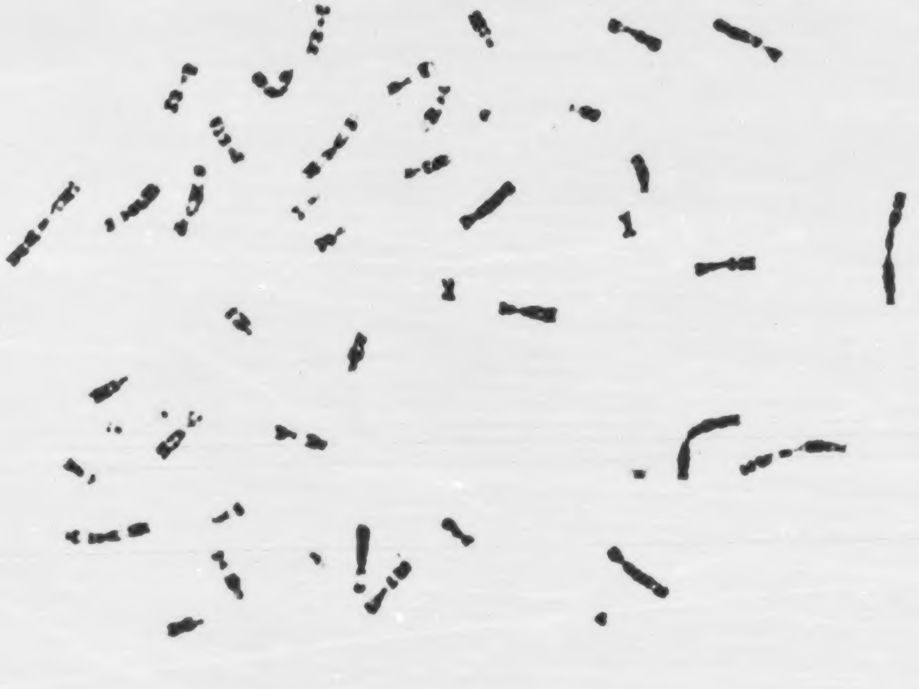
The chromosomes in human karyotypes usually are from white blood cells. A mature red blood cell does not have a nucleus, but a white cell does. Scientists grow new cells from white blood cells they remove from a blood sample. They observe the nuclei (NEW klee eye; plural of nucleus) of these cells under a microscope.

Before a cell beings to divide, its chromosomes are a tangled mass of fibers in the nucleus. When cell division begins, the chromosomes change into tightly packed bodies that can be seen easily with a microscope.

At one stage during cell division, called metaphase, the chromosomes line up near the middle of the cell. Scientists can add a chemical to the cell to stop cell division at this stage. The chromosomes are not pulled apart as they would be if the cell was allowed to divide normally. Instead, the chromosomes remain in the center of the nucleus.

The scientists then add another chemical that causes the nucleus of each cell to swell and burst. These cells can be put on a slide and stained. The stain will make certain parts of the chromosomes darker than others. This makes a pattern of bands. Each pair of chromosomes has a different banding pattern.

The scientists take pictures of the stained chromosomes. Then they cut the pictures apart. When they match the chromosomes that look alike, they have the pairs of chromosomes that appear in a karyotype. You will be using karyotypes in this activity.



Directions

1. Work in small groups to examine the two sets of pictures of chromosomes that appear on pages 39 and 40.

Questions for Discussion I

Study the pictures with other students in your group. Discuss these questions and write down your answers.

1. How are the pictures alike?

2. How are the pictures different? (Look carefully at each pair of chromosomes.)

3. How many chromosomes are in each picture?

	Set A	Set B
Top	______	______
Bottom	______	______

4. What similarities of the chromosomes did people use when they made the karyotypes?

5. How many chromosomes are in each group?

6. How many of each pair were contributed by the mother? ________

by the father? ________

ARCHITECTS AND CHROMOSOMES*

Maybe you have wondered how genes and chromosomes that are too small to be seen can produce characteristics like the shape of your nose or the color of your hair. Think of it this way: The relationship between the chromosomes and a characteristic is like the relationship between architects and a town.

The architects give their instructions—their plans—for the building of the houses and shops. When these are built and arranged, a town is formed. A town is certainly not a collection of architects. It is the product of their instructions. Similarly, a characteristic is the product of the instructions from the chromosomes.

The individual shops and houses built from the architects' instructions are not the town. The town only comes into being when they are all built and arranged in a certain way. And the cells built from the chromosomes' instructions do not produce a characteristic unless the cells are built and arranged in a particular way.

The building of a town is a three-stage process:

ARCHITECTS
give instructions
HOUSES AND SHOPS
in a pattern
TOWN

So is the building of a characteristic:

CHROMOSOMES
give instructions
CELLS
in a pattern
CHARACTERISTIC

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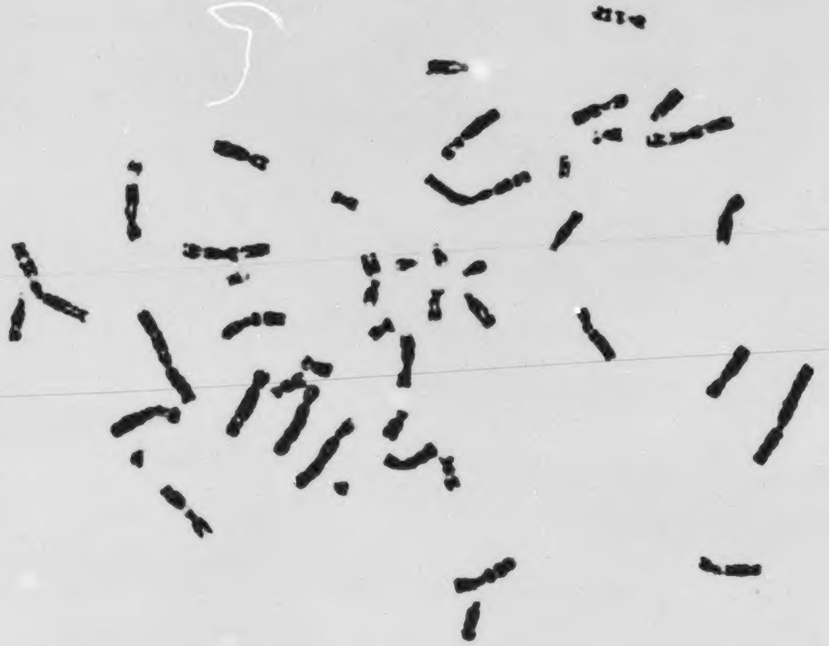
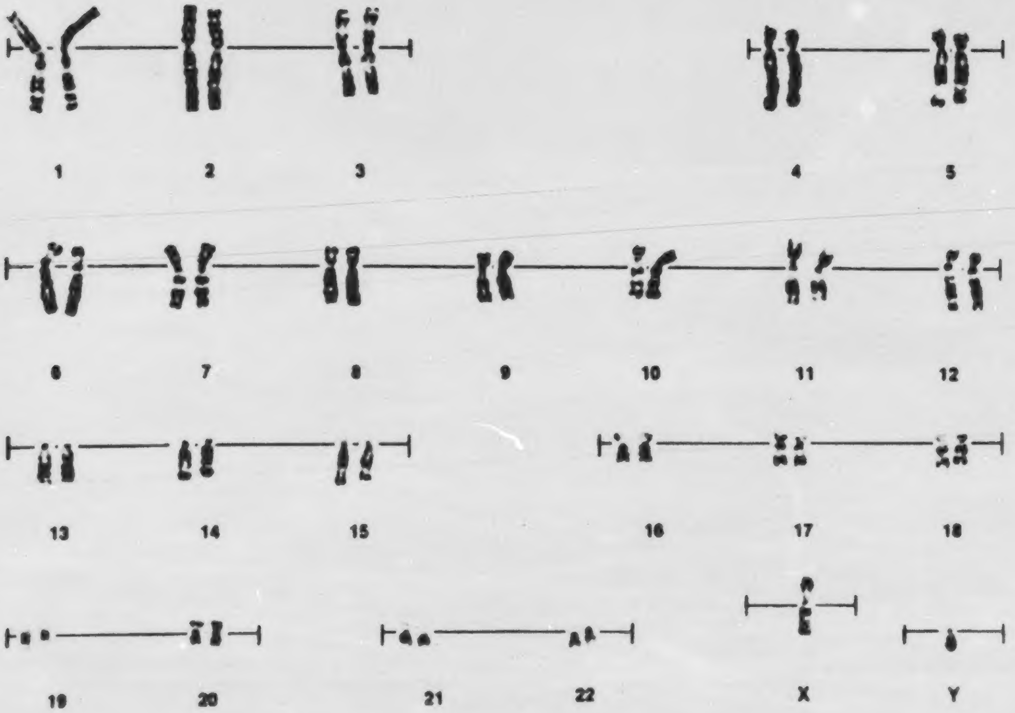
*Adapted with permission from *Biology Text V, The Perpetuation of Life,* © 1967 by the Nuffield Foundation, England, page 73.

SET A

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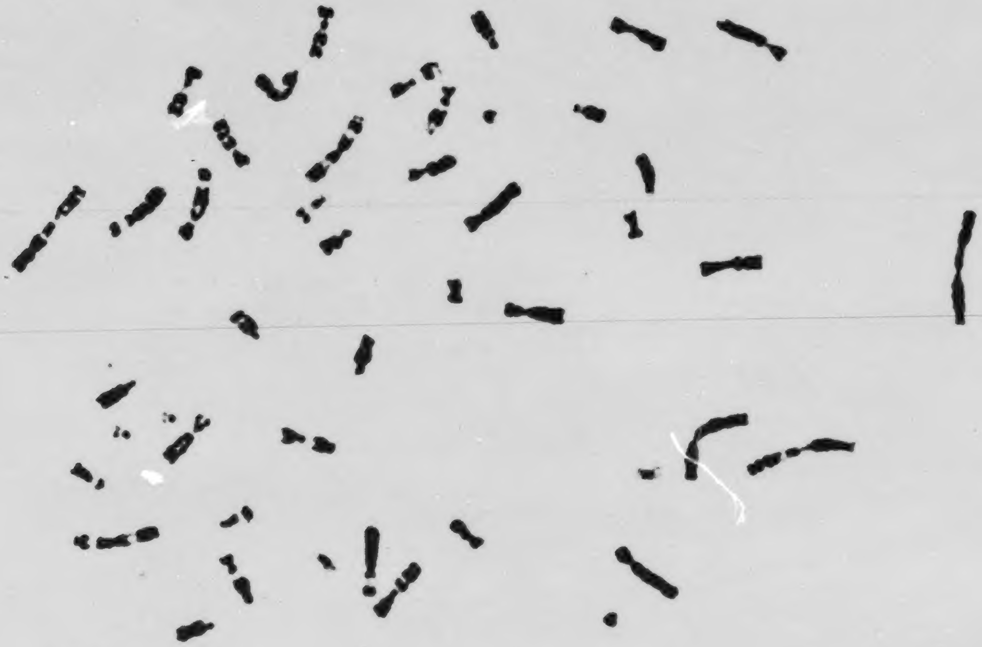
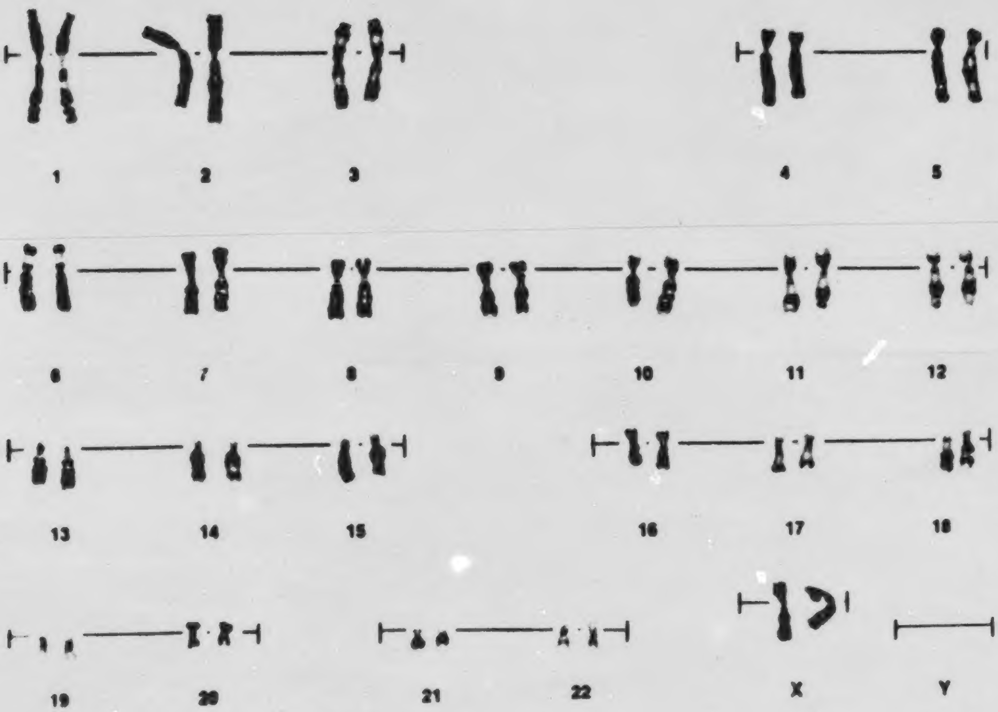
Y

39

SET B

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20
21
22
X
Y

Questions for Discussion II

1. Review what you have just read. Why is it important that each cell have chromosomes?

2. Information on chromosomes controls the work of cells. These instructions keep you alive. What kinds of activities have to be performed by your body to keep you alive? List as many as you can.

Going Further

Look through recent newspapers and magazines for an article about chromosomes. What does the article say about them? Did you understand everything in the article? How could you find out more about the topic?

Self Quiz

1. How many chromosomes do most human beings have in each body cell?
2. Where will you find chromosomes in your body?
3. Where are instructions for building cells?
4. Cells are arranged in special ways to make a characteristic. One example of such a characteristic is a dimple. Name three more examples.

Activity 8

SEX CHROMOSOMES

Look back at the karyotypes on pages 39 and 40. Look carefully at the last two chromosomes in each picture.

These are the sex chromosomes. The larger one is the X chromosome. The smaller one is the Y chromosome. These two kinds of chromosomes determine whether a child will be a boy or a girl.

Each of the mother's egg cells contains one X chromosome. Half of the father's sperm cells contain one X chromosome. The other half contain one Y chromosome. There are two possible combinations. If two X chromosomes combine in the fertilized egg, the child will be a girl. If an X combines with a Y, the child will be a boy.

EGG	SPERM		
X	X	=	Girl
X	Y	=	Boy

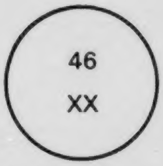
What are the chances that a baby will be a girl, or a boy? What are the chances that a couple will have all boys, or all girls? In this activity, you and a partner will use a game to figure out some of these chances.

Materials

Inheritance Spinner
Transparency overlays: Sex Chromosomes (A, B, C)
Push pins
Scissors

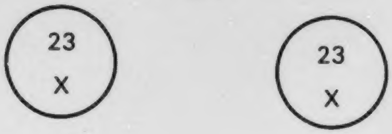
Directions

1. Look at the overlay pictures shown by your teacher. Chromosome sets are different in males and females.
2. This circle stands for a body cell from a woman. How many chromosomes does it have?

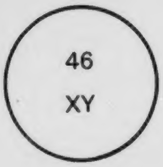
   What sex chromosomes does it contain?

   These circles stand for the woman's egg cells. What sex chromosome is in each egg cell?

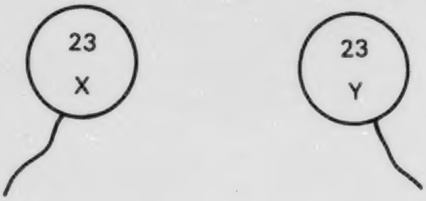
   What is the total number of chromosomes in each egg cell?

3. This circle stands for a body cell from a man. How many chromosomes does it have?

   What sex chromosome does it contain?

   These figures stand for the man's sperm cells. What sex chromosome is in each sperm cell?

   What is the total number of chromosomes in each sperm cell?

4. What will be the total number of chromosomes when an egg cell and a sperm cell combine?
5. Place the Inheritance Spinner on the table before you. Look at the two wheels. One wheel selects the sex chromosome that comes from the father. The other wheel selects the sex chromosome that comes from the mother.
6. Twirl each pointer. What two sex chromosomes did you get?

   Would a child with these chromosomes be a boy or a girl?

7. Look at the spinner carefully. Can you figure out what chance the child had to be the other sex?

   What are the chances that the child will be a girl?

   What are the chances that the child will be a boy?

8. In the space below, show all the pairs of sex chromosomes that might occur when a sperm and an egg combine.

9. Use the Inheritance Spinner to determine more about the chances that a child will be a boy or a girl. Twirl the spinner 10 more times. Use this chart to record your results.

CHILD NUMBER	CHROMOSOMES	SEX	CHILD NUMBER	CHROMOSOMES	SEX
1			6		
2			7		
3			8		
4			9		
5			10		

Questions for Discussion

Discuss the following questions with your classmates. Write your answers in the space below each question.

1. What is the total number of chromosomes in an egg cell?

   What is the total number of chromosomes in a sperm cell?

2. From which parent does a boy inherit

   his X chromosome?

   his Y chromosome?

3. From which parent does a girl inherit

   her X chromosome?

   her other X chromosome?

4. Could a son inherit the genes carried on his father's X chromosome?

   Explain your answer.

5. Look at the Inheritance Spinner. Then look at your answers under Steps 5, 6, and 7 in the Directions. *Each time* a child is formed, what are the chances it will be

   a boy?

   a girl?

6. Mr. and Mrs. Smith have three daughters. They are expecting another child. What are the chances that the next child will be a girl?

Going Further

1. Contact your city or county health department. Find out whether more boys or girls are born in your area each year.
2. Twirl the Inheritance Spinner 50 times. Keep a record of your results. How many twirls resulted in boys? How many resulted in girls? Compare the two numbers.

Self Quiz

1. A couple has four sons. Their chance of having another son when the next child is born is

   _____ a. the same as before.

   _____ b. greater than before.

   _____ c. less than before.

2. The person whose sex chromosome determines if the child has a Y chromosome is

   _____ a. the mother.

   _____ b. the father.

   _____ c. both mother and father.

3. A child with one X chromosome and one Y chromosome is

   _____ a. a boy.

   _____ b. a girl.

Activity 9

A MATTER OF CONTROL

Look back at the pedigree charts you made in Activity 6. What characteristic did you study? Did several people in the family have the same characteristic?

Have you ever noticed that, when a black dog and a white dog mate, many of their puppies are black?

A lot of scientists noticed these things, too. To explain how this happens, they use two words: *dominant* and *recessive*. Dominant means being expressed. recessive means being hidden, or not expressed. Scientists use these words to explain why some characteristics show up instead of others.

Scientists say *expressed* when they talk about characteristics. A characteristic is "expressed" if it shows up in an individual. Expressed means the characteristic can be observed.

In this activity, you will have a chance to figure out how these words are used to describe patterns of inheritance.

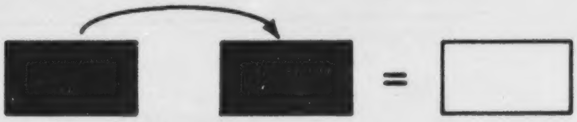
Materials

2 strips of construction paper
2 strips of clear plastic

Directions

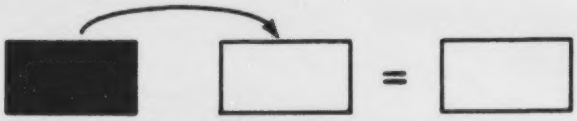
1. Get the strips of paper and plastic from your teacher. Place them on the table in front of you. Imagine that each strip is a gene. The dark strips are dominant genes. The clear strips are recessive genes.
2. Place one dark strip on top of the other dark strip. What do you observe?

   The dark strips stand for dominant genes. These genes contain the same information. The characteristic caused by these genes will be expressed in the individual. Shade the picture to show this combination of dominant genes.



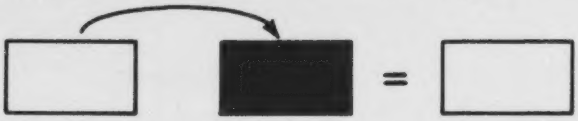
3. Place a dark strip over a clear strip. What do you observe?

   The dark strip stands for a dominant gene. The clear strip is a recessive gene. The characteristic caused by the dominant gene will be expressed. Color the picture to show the combination of a dominant gene and a recessive gene.



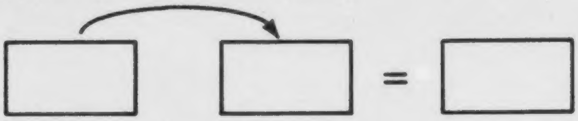
4. Place a clear strip over a dark strip. What do you observe?

The dark strip is a dominant gene and the clear strip is a recessive gene. The characteristic that is expressed is the one carried by the dominant gene. It is not the one carried by the recessive gene. The individual will look the same as the one in Step 3. Color the picture to show the combination of a recessive gene and a dominant gene.



5. Place one clear strip over the other clear strip. What do you observe?

In this pair of genes, the characteristic carried by the recessive genes is expressed. Two recessive genes can determine how the individual will look. Color the picture to show the combination of a recessive gene with a recessive gene.



6. Return your strips to your teacher. Then summarize your data in the drawings below. Use a capital letter (D) to stand for dominant genes. Use a small letter (d) to stand for recessive genes.

Shade or leave white the strips and write a letter (D = dominant, d = recessive) above each box to show whether it is a dominant or a recessive gene.

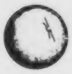
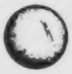
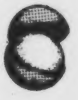
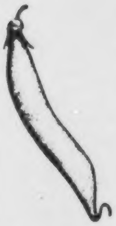
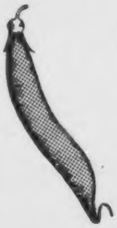
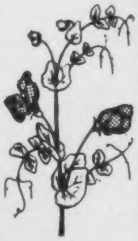
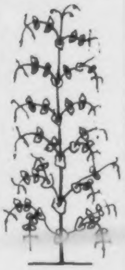
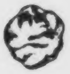
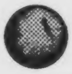
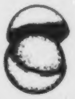
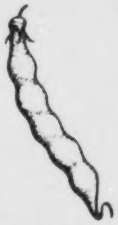
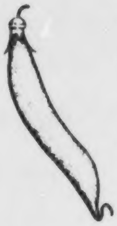
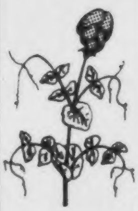
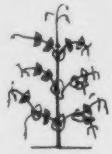
DOMINANT	DOMINANT	The characteristic expressed (that shows up) is the one caused by the _____ dominant gene. _____ recessive gene.
DOMINANT	RECESSIVE	The characteristic expressed is the one caused by the _____ dominant gene. _____ recessive gene.
RECESSIVE	DOMINANT	The characteristic expressed is the one caused by the _____ dominant gene. _____ recessive gene.
RECESSIVE	RECESSIVE	The characteristic expressed is the one caused by the _____ dominant gene. _____ recessive gene.

PEAS AND PEOPLE

A long time ago, a man named Gregor Mendel lived in Austria. Mendel was a monk. He had a big garden, and he grew a lot of peas in it. Mendel noticed that the pea plants had different kinds of flowers, different kinds of stems, and different kinds of pea pods. He experimented. He crossed the different kinds of plants and produced new plants. Mendel learned that some of the characteristics—round seeds and long stems, for example—showed up in the plants produced by these crosses. Others did not.

Mendel called the characteristics that showed up *dominant.* He called the ones that did not show up *recessive.* Mendel didn't know about genes. But he suspected that something was passed from one generation to the next. And he thought that the "something" caused certain characteristics to show up.

The seven characteristics of garden peas studied by Mendel

SEED SHAPE	SEED COLOR	SEED-COAT COLOR	POD SHAPE	POD COLOR	FLOWER POSITION	STEM LENGTH
 round	 yellow	 colored	 inflated	 green	 axial	 long
 wrinkled	 green	 white	 constricted	 yellow	 terminal	 short

Today, we understand this a lot better than Mendel did. We know that if one dominant gene occurs in a pair of genes, its characteristic will be expressed. But the recessive gene does not disappear. It just is not expressed. And the recessive gene can be passed on to the next generation. If, in the next generation, that recessive gene is paired with another recessive gene, its characteristic will be expressed.

This explains why a characteristic sometimes skips a generation or two before it shows up again. This is why you may have a characteristic your grandfather has; yet your parents do not have it.

On a pedigree chart, scientists use different kinds of letters to stand for different kinds of genes. They use capital letters to stand for dominant genes. They use small letters to stand for recessive genes. The letter they use is usually the initial of a word that describes the characteristic. For example, they say that black (B) is dominant over white (b).

In Activity 6 you used pedigree charts to show how different characteristics pass from one generation to another. A few of these genes may cause medical problems. Pedigree charts can help doctors figure out how these problems might be inherited.

A dominant gene is rather easy to follow, if you have complete information for your chart. A recessive gene may be hidden. It may be in a pair with a dominant one. In this case, its characteristic would not show up. When a recessive gene that causes a medical problem is paired with another gene just like it, an individual has the medical problem.

When this happens, we can assume that the parents of the individual each had a recessive gene for the problem. People who have recessive genes for a medical problem but do not have the problem are called carriers. They are not affected by the gene, but their children might be.

Questions for Discussion

Discuss the following questions with other students. Write your answers in the space below each question.

1. Is the characteristic of a dominant gene expressed if the gene is paired with another dominant or recessive gene?

   Give an example to support your answer.

2. Is the characteristic of a recessive gene expressed when the gene is combined with another recessive gene?

   Give an example to support your answer.

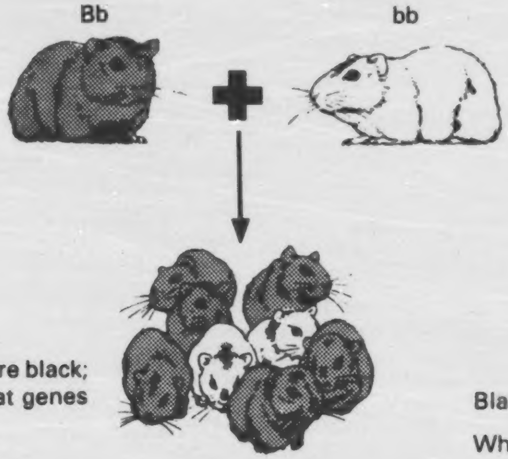
3. What happens if a dominant gene is paired with a recessive gene?

4. A white male dog is mated with a black female dog. The following gene pairs are in the puppies. Black genes (B) are dominant; white genes (b) are recessive. Complete the table to show which genes would be expressed in each puppy.

PUPPY	GENE EXPRESSED	CHARACTERISTIC EXPRESSED (Color of Puppy)
BB		
Bb		
bB		
bb		

5. Genes for black color also are dominant (B) in guinea pigs. Genes for white are recessive (b). When a black guinea pig is mated with a white one, most of the babies will be black. Sometimes all of them will be black. Let's see if we can figure out why this happens.

The mother
is black.
Her genes
are Bb.



The father
is white.
His genes
are bb.

Some of their babies are black; some are white. What genes do the babies have?

Black ones have _____

White ones have _____

From which parent did the babies get each of their genes?

Black babies: _____ from mother; _____ from father.

White babies: _____ from mother; _____ from father.

Suppose all the babies were black.

In this case, what genes would the mother probably have? __________

Going Further

1. Look in a genetics or biology book to find other examples of dominant and recessive characteristics.
2. Use the encyclopedia or biology books to learn more about pedigrees. Look up the pedigree charts that show the Hapsburg line of European nobles. What characteristics seem to be dominant?
3. Try to find pedigree charts of English (or another nationality) nobility or everyday people.

Self Quiz

1. In your own words, write the meanings of

   Dominant:

   Recessive:

2. Explain how two dogs that have black hair could have a puppy with white hair.

Activity 10
PREDICTING INHERITANCE

What characteristics did you inherit from your parents? The characteristics you inherited are controlled by the genes carried on your chromosomes. And genes, like chromosomes, come in pairs.

Some characteristics may be controlled by one pair of genes. Other characteristics, like eye, hair, and skin color, may be controlled by many pairs of genes working together.

In this activity, you will have a chance to learn more about characteristics that are controlled by one pair of genes. You will see how dominant and recessive genes affect the way characteristics are inherited.

Materials

Inheritance Spinner with 6 spinner cards
2 push pins
Scissors

Directions

1. The chart below lists some human characteristics that are determined by genes. The letters tell if the gene is dominant or recessive.

   Capital letters stand for dominant genes. Small letters stand for recessive genes. Notice that different letters have been used for different characteristics. Characteristics caused by dominant genes will be expressed when the dominant gene is paired with another dominant gene. It will also be expressed if the dominant gene is paired with a recessive gene.

CHARACTERISTIC	DOMINANT GENE	CHARACTERISTIC	RECESSIVE GENE
Extra finger	F	No extra finger	f
Cleft chin	L	Smooth chin	l
Crooked little finger	B	Straight little finger	b
Widow's peak	A	Smooth hairline	a
Hairy fingers	H	Hairless fingers	h

Complete the following chart. Fill in the symbols for each gene in the gene pair. Then write the characteristic that will be expressed (show up) in the individual.

ONE GENE	THE OTHER GENE	GENE PAIR	CHARACTERISTIC THAT IS EXPRESSED
Hairy fingers (H)	Hairless fingers (h)		
Hairless fingers ( )	Hairless fingers ( )		
Cleft chin ( )	Smooth chin ( )		
Cleft chin ( )	Cleft chin ( )		
Crooked little finger ( )	Crooked little finger ( )		
Extra finger ( )	No extra finger ( )		
No extra finger ( )	No extra finger ( )		

The small letters stand for recessive genes. Recessive genes are not expressed when paired with a dominant gene. Characteristics caused by recessive genes are expressed (can be seen) when only recessive genes are present.

2. Look at your Inheritance Spinner. Now look at the six spinners. The cards show some gene pairs. Notice the different pairs of genes that can be in one person. What different types of gene pairs do you see?

   List the gene pairs on the spinners that contain dominant genes.

3. Use the following example of a characteristic as you put your Inheritance Spinner together.

   (a) Widow's peak is a dominant (A) characteristic; smooth hairline is a recessive (a) characteristic. The father has two dominant genes. The mother has two recessive genes. One gene comes from the father to the child, and one gene comes from the mother.

   Follow these directions:

   (1) Cut out the 6 spinners. Punch a hole in the center of each one.

   (2) Choose the spinner that stands for the father's two dominant genes (AA). Place it on the Inheritance Spinner.

   (3) Choose the spinner that stands for the mother's two recessive genes (aa). Place this on the Inheritance Spinner.

   (4) Twirl each pointer. Record the gene pairs you get on the Gene Pair Chart.

   Note: You may be able to fill in this chart without using the Inheritance Spinner.

GENE PAIR CHART (a)	
Mother aa	Father AA

record gene pairs here →

GENE PAIRS IN CHILDREN	CHARACTERISTIC THAT IS EXPRESSED

4. Use the Inheritance Spinner with these examples. Record your results in the Gene Pair Charts. First, fill in the boxes for the Mother's gene pair and for the father's gene pair. Then, twirl the pointers three times for each example. How many different pairs did you get?

(b) MOTHER: Widow's peak
(2 dominant genes)

FATHER: Widow's peak
(2 dominant genes)

(c) MOTHER: Smooth hairline
(2) recessive genes)

FATHER: Smooth hairline
(2) recessive genes)

GENE PAIR CHART (b)

MOTHER	FATHER

GENE PAIRS IN CHILDREN	CHARACTERISTIC THAT IS EXPRESSED

GENE PAIR CHART (c)

MOTHER	FATHER

GENE PAIRS IN CHILDREN	CHARACTERISTIC THAT IS EXPRESSED

5. Sometimes parents have a recessive, or hidden, gene combined with a dominant gene. What gene pairs could occur in their children when this happens? Use these examples to find out what can happen when one or both parents have a recessive gene. Use the chart under Step 1 to help fill in the blanks. Compare your answers to the answers of your classmates.

(d) MOTHER: Widow's peak
(2 dominant genes)

FATHER: Widow's peak
(1 dominant gene,
1 recessive gene)

(e) MOTHER: Widow's peak
(1 dominant gene,
1 recessive gene)

FATHER: Widow's peak
(1 dominant gene,
1 recessive gene)

GENE PAIR CHART (d)

MOTHER	FATHER

GENE PAIRS IN CHILDREN	CHARACTERISTIC THAT IS EXPRESSED

GENE PAIR CHART (e)

MOTHER	FATHER

GENE PAIRS IN CHILDREN	CHARACTERISTIC THAT IS EXPRESSED

Questions for Discussion I

Write True or False next to each of the following statements. Discuss your answers with other students.

________ 1. Genes carry information for characteristics such as eye and hair color.

________ 2. Each characteristic in humans is controlled by one or more pairs of genes.

________ 3. All characteristics are caused by dominant genes.

________ 4. The characteristic caused by a dominant gene shows up over the one caused by a recessive gene.

________ 5. A child inherits one gene for a characteristic from each parent.

Going further

Use the following examples and the Inheritance Spinner. The chart under Step 1 of the Directions shows the letter symbols for the genes that cause these characteristics. Write the gene pairs on the Inheritance Spinner. Make a Gene Pair Chart for each of the following crosses and record your results.

MOTHER	FATHER
(1) Hairless finger	**Hairy fingers (2 dominant genes)**
(2) Smooth chin	**Cleft chin (1 dominant gene, 1 recessive gene)**
(3) Smooth chin	**Smooth chin**
(4) Extra finger (2 dominant genes)	**Extra finger (1 dominant gene, 1 recessive gene)**
(5) Extra finger (1 dominant gene, 1 recessive gene)	**Extra finger (1 dominant gene, 1 recessive gene)**

GENES AND CHARACTERISTICS

The chromosomes in the nucleus of a fertilized egg occur in pairs. The mother's egg contains one member of each pair. The father's sperm contains the other member of each pair. When the egg and sperm unite, the fertilized egg has two of each kind of chromosome.

Each chromosome carries the genes for certain characteristics. And the genes occur in a certain order on that chromosome. When the two chromosomes of a pair come together, the genes on these chromosomes also come together. Thus, each pair of chromosomes contains many pairs of genes, as shown in Figure 6.

Different genes cause different things to happen. And genes usually occur in pairs. Many characteristics are controlled by more than one pair of genes. Hair color and eye color, for example, are determined by many pairs of genes.

Some genes are dominant. The characteristic caused by the dominant gene in a gene pair is always expressed—can be seen—in a person who has that gene. The characteristic carried by the other gene is not expressed. This other kind of gene is recessive. In order for its characteristic to be expressed, a recessive gene must be paired with another recessive gene.

An example of this relationship is hair on the fingers. If a person has this dominant gene, he or she will have hair on the fingers. Hair will not occur on the fingers of a person who does not have the dominant gene.

Figure 7 shows two Punnet Squares. Scientists use Punnet Squares to figure out the possible gene pairs that can come from two parents. The first Punnet Square shows the father's genes at the top and the mother's genes at the side of the square. In the boxes inside the square, we can put all the gene pairs for a given characteristic that could come from these parents.

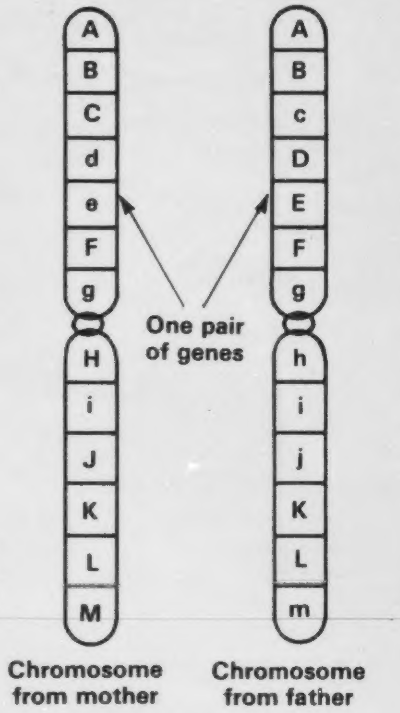
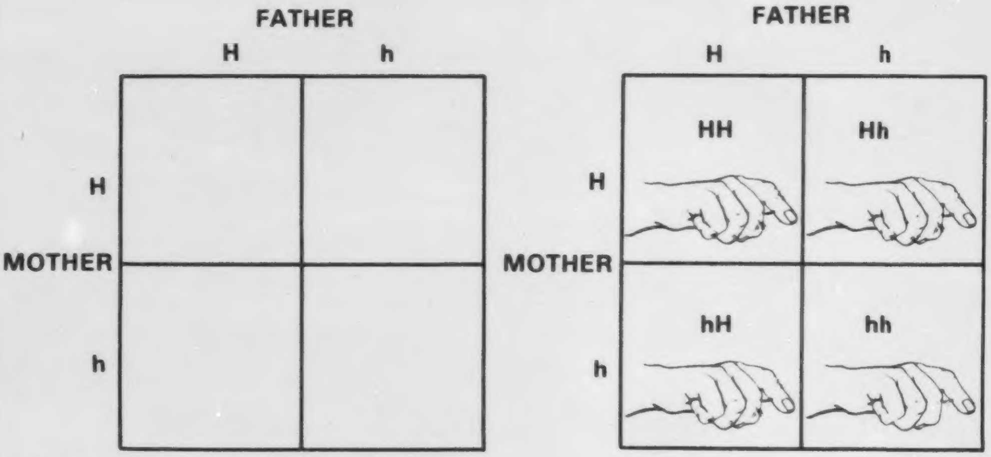


Figure 6. A pair of chromosomes may have two dominant genes (two capital letters), two recessive genes (two small letters), or one of each.

First, we put the Father's H gene in the two boxes just below it. Then, we put his h gene in the two boxes below it. Next, we look at the Mother's genes. We add her H gene to the two top boxes. And we add her h gene to the two bottom boxes. The second Punnet Square shows how this will look.

How many *different* gene pairs are there?



		FATHER	
		H	h
MOTHER	H		
	h		

		FATHER	
		H	h
MOTHER	H	HH	Hh
	h	hH	hh

Figure 7.

How many of these gene pairs would cause hairy fingers?

Which ones are they?

How many pairs would not cause hairy fingers?

Questions for Discussion II

Write True or False next to each statement. Discuss your answers with other students.

________ 1. The type of blood you have is determined by your genes.

________ 2. "Ff" indicates a person who has one dominant gene and one recessive gene for a characteristic.

________ 3. A recessive gene is expressed when paired with a dominant gene.

________ 4. Hair color probably is caused by many pairs of genes.

________ 5. It is easy to predict inheritance in humans.

Self Quiz

1. Complete the following statement: Human characteristics are controlled by genes that come equally from a ____________ and a ____________.
2. How many dominant genes must be present for a characteristic to be expressed?
3. A mother and father each have one dominant and one recessive gene for widow's peak (Aa). What is the probability that their child will have widow's peak?

   What is the probability that their child will have a smooth hairline?

Activity 11

GENETIC CONDITIONS

Each of your tiny chromosomes carries thousands of genes. These genes carry information that affects what you look like and how your body works. Thousands of genes are responsible for the many differences among human beings. For the most part, these differences just provide variety in people.

Once in awhile, however, a gene occurs that may cause a problem. Examples are the genes that cause cystic fibrosis, sickle-cell anemia, and Tay-Sachs. Do you know anything about these genetic conditions?

In this activity, you will read about people who have these conditions. Try to imagine what it would be like to be one of them. What questions would you have? How would you feel?

Directions

1. Work in small groups. Each group will work on one case history.
2. Read the story. These are true stories, but the names have been changed.
3. Write your answers to the Questions for Discussion below. Discuss your answers with the other students in your group.
4. When all the groups are finished, one or two students should summarize each case history for the class.

Questions for Discussion

Write your answers to the following questions, based on the case history you read. Discuss your answers with other students in your group.

1. What is the name of the condition you read about?
2. What are some of its characteristics?
3. What treatment is available?
4. Would it be possible for other children to catch the condition from someone who has it?
5. Does it follow a dominant or a recessive pattern of inheritance?
6. What would it be like to have this condition?
7. Do all genetic differences cause medical problems? Explain your answer.

Case History
"MY BROTHER, B.J."

My brother, B.J., has Tay-Sachs (TAY-SACKS). That may not sound too bad, but when I found out that B.J. had Tay-Sachs, it was the worst day of my life.

Kids with Tay-Sachs die before they're four years old. B.J. is almost two now. I'm getting used to the idea that he's going to die, but it isn't easy. I'll explain what happened.

My sister, Marcie, and I were really excited when B.J. was born. I answered the phone when Dad called. He said, "Steven, you've got the baby brother you wanted!" Finally, a brother!

B.J. looked just like other babies. He was tiny and slept a lot at first. When he got hungry, he sure did scream! My friends would come over, and we'd make faces so B.J. would laugh. He watched everything. He learned how to sit up before his older cousin did. When he started to crawl, we had to hide all kinds of things so he wouldn't put them in his mouth. B.J. was lots of fun to have around.

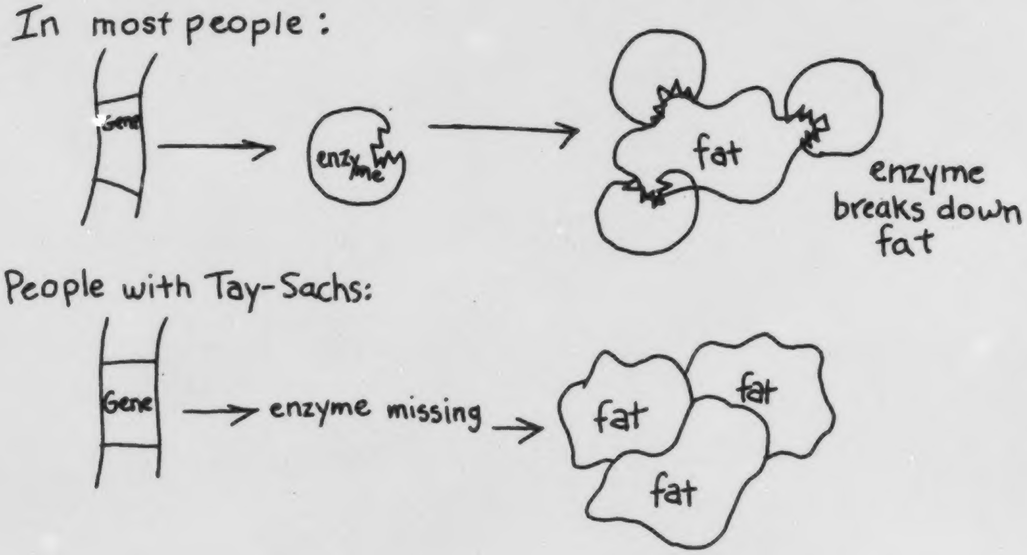
Then, B.J. started to change. We didn't notice it at first. But now, when I think back, I can remember how he was changing. One day I ran home to watch B.J. while Mom went to the store. The screen door slammed behind me, and B.J. jumped more than he usually did. He wasn't moving around as much as he used to. He wouldn't crawl, and he'd fall over when he was sitting up. It was like he was a little baby again. We were all getting worried because he wasn't smiling much anymore. And we had to be quiet. Every little noise would startle him.

My parents took B.J. in for a check-up when he was eight months old. That was the day I learned those words—Tay-Sachs. The doctor told Mom and Dad that B.J. was born with Tay-Sachs. He said there was nothing we could do to help B.J.

Nobody talked much that night. We kept looking at B.J. How could this happen to him?

Tay-Sachs is a recessive genetic condition. No one knows why, but it's more common in Jewish people than in other people. Kids who have Tay-Sachs can't break down a certain kind of fat in their bodies. The fat has to be broken down before the body can use it.

Because he has Tay-Sachs, B.J. doesn't have the enzyme he needs to break down that fat. He doesn't have the gene that he needs to make the enzyme. Mom drew this picture when she explained it to me. The fat piles up in the brain cells. Finally, the brain cells die.



That is what's happening to B.J. His brain cells are being destroyed. Dad says there aren't any pills that can help him. I asked about an operation, but that wouldn't help, either. In fact, there is nothing doctors can do to help B.J.

Now, B.J. just lies still. He won't look at me when I talk to him. Even Marcie can't get him to smile. Mom doesn't think B.J. can see anymore. He can't eat and we have to feed him with a tube. For awhile he was limp, but now he feels stiff. The doctor says it's going to get harder and harder to take care of him. Mom and Dad have looked for a hospital that he can stay in. Sometimes I wish that he'd hurry up and die. When I feel like that, I get scared and I run in and hold him tightly.

Marcie and I could be carriers for Tay-Sachs. That means that we could have one gene for Tay-Sachs. Mom and Dad are carriers. They each have one gene for Tay-Sachs. B.J. wasn't very lucky. He got a Tay-Sachs gene from Dad and one from Mom. If a person has two tay-Sachs genes, that's when they're in trouble.

A simple test will find out if Marcie and I are carriers. People at a clinic can take a little of our blood and test it. The doctor said we probably would want to take the test when we're older.

I wonder...am I a carrier for Tay-Sachs?

Case History
"JEFF, TOO?"

Janet Taft was very excited when her brother was born. She planned the games they would play. She decided which toys he could have. She even knew the kind of club house they would build. Like many four-year-olds, she didn't understand what a baby can and cannot do. Janet had all kinds of questions. Where would the baby put his toothbrush? Would he have to take pills everyday? Would he have to do lung exercises?

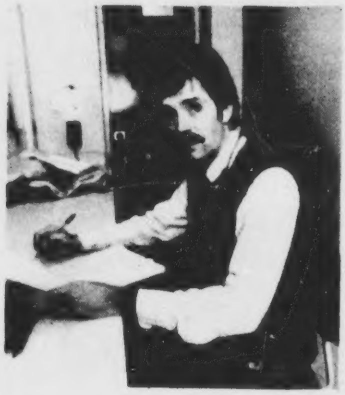
Her parents were asking some of the same questions. Would Jeff have to take pills and do special exercises like Janet did?

When Janet was born, she seemed very healthy. Janet was happy. She loved to be held and was always hungry. But when she was about three months old, she started to cough. It wasn't a big cough. It was just a little one that wouldn't go away. Her parents took her to the doctor to find out why she was coughing.

At first, Dr. Fisk couldn't figure it out. He noticed that Janet was smaller than other babies her age. Mr. and Mrs. Taft explained that Janet was a good eater. She ate all of the time but didn't seem to gain weight. This worried Dr. Fisk. What could be wrong?

Then Mr. Taft gave an important clue. He said that he and his wife noticed a salty taste when they kissed Janet. Now, Dr. Fisk had an idea what Janet might have. But first, he had to make some laboratory tests.

When the test results were back, the Tafts returned to Dr. Fisk's office. He told them that Janet had cystic fibrosis. They had heard of cystic fibrosis before but didn't know what it was. This is what the doctor told them:



"Cystic fibrosis is a recessive genetic condition. It is the most common genetic condition in white people. The ducts and glands in the bodies of people with cystic fibrosis do not work properly. For example, the sweat glands usually are affected. There is more loss of sweat than there should be. That's why Janet 'tastes salty.'

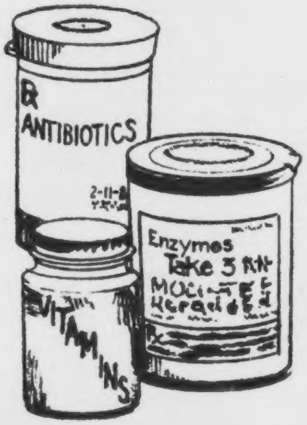
"Another serious problem involves the lungs. All of the small air passages in the lungs become filled with fluid. Breathing becomes difficult. When Janet coughs, she is trying to clear the fluid out of her lungs.

"The glands in the digestive system often become clogged. when this happens, enzymes needed for digestion can't get to the food. That's why Janet is not gaining weight, even though she eats all the time."

Mr. and Mrs. Taft were very worried! Janet had breathing problems, she could not digest her food properly, and her body was losing too much salt. What could they do to help her?

While the doctor talked, Janet played with her rattle and kicked her feet. The doctor explained what could be done for her:

"At this time, we have no cure for cystic fibrosis. Janet will have to take many kinds of pills. She will need antibiotics to help her body fight infections. She'll need enzyme tablets to break down her food so she can gain weight and grow. Daily vitamins will supply some of the nutrients her body can't get from her food.



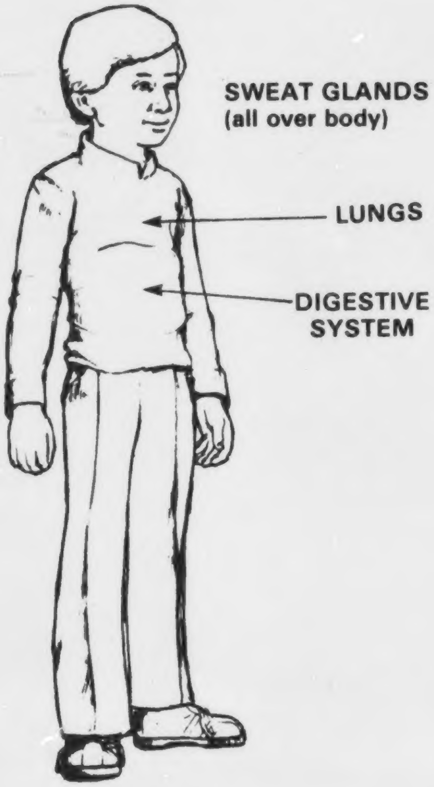
"And you will have to keep her lungs free of fluid. This means you will have to pound gently on her chest to help her cough up the fluid. This is a kind of exercise.

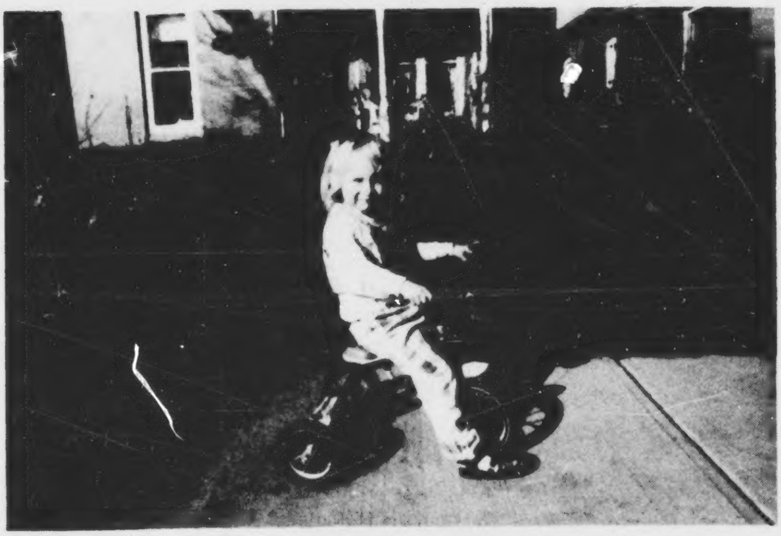
"She'll always have a slight cough. Try not to worry about the cough too much."

All of this happened four years ago. Janet has been taking her pills each day. Her parents have been helping to keep her lungs clear of fluid. She has been a happy little girl.

Janet knows she can't run as much as other children or play rough games. But, in most ways, she is just like other four-year-olds. Janet loves peanut-butter sandwiches, chocolate milk, and cookies. She doesn't like to go to bed, and she watches "Sesame Street" every afternoon. But right now, she doesn't care about television or food. She wants to see her baby brother, Jeff.

Jeff has been taking a nap for almost two hours. Janet keeps tiptoeing into his room to see if he's awake. Jeff looks very healthy. Mr. and Mrs. Taft have been talking about Jeff's future. The doctor told them that cystic fibrosis was a genetic condition. Now, they want to know, does Jeff have cystic fibrosis, too?





Case History
"JUST ASK JASON"

Mary Fulcher is 13 years old. She is in the seventh grade at Lindbergh Avenue Middle School in St. Louis. Mary's teachers know her as an excellent student with many interests. She is in the Math Club, plays on the school's volleyball team, and is learning to play the flute.

Many of Mary's teachers remember her older brother, Mark. Mark is almost 19 now. He is just finishing his freshman year at UCLA in California. Mark's interests were a bit different from Mary's, but he was an excellent student, also. Like Mary, Mark was well liked and respected by his classmates.

None of the teachers ever knew that Mark had sickle-cell trait. They do not know that Mary has it, either. In fact, no one would ever know unless Mary or Mark chose to tell them.

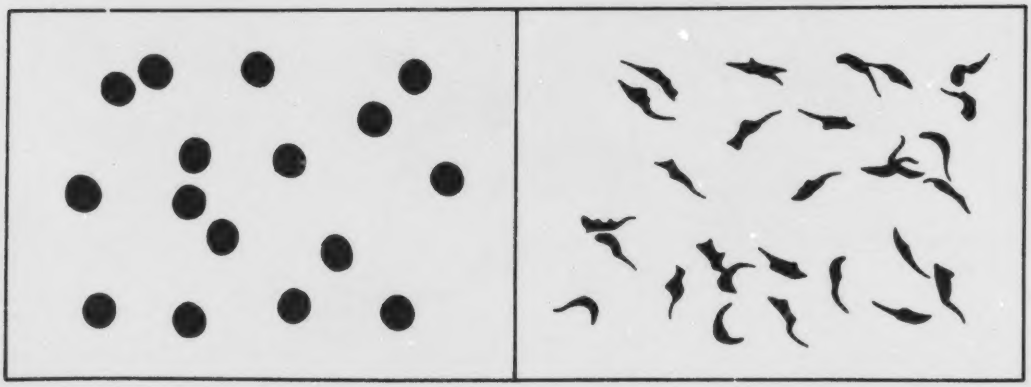
Sickle-cell trait is not a disease. And it does not make you sick. People with sickle-cell trait have one gene for sickle-cell anemia, not two. And the sickle-cell gene is recessive. People with only one sickle-cell gene do not have sickle-cell anemia.

Mary, Mark, and their parents are worried about Jason. Jason is the youngest of the Fulcher children. He will start sixth grade next year. And he will go to Lindbergh Avenue Middle School with Mary. Jason will meet a whole new group of students. These students will ask why Jason is so small, why he gets tired so easily, and why his arms and legs sometimes hurt.

Jason has sickle-cell anemia. He inherited genes for sickle cell from both parents. Mary and Mark each inherited only one gene for sickle cell. That is why they have sickle-cell trait. And that is why Mark and Mary do not have the medical problems that Jason sometimes has.

Sickle-cell trait and sickle-cell anemia are genetic conditions that are most common in Black people. About one out of every ten Blacks in the United States has the gene for sickle-cell trait. About one out of 500 Black Americans has sickle-cell anemia. Sickle-cell trait and sickle-cell anemia also are found in people from Italy, Sicily, Greece, Turkey, and other countries around the Mediterranean Sea.

The gene for sickle cell affects the red blood cells, which carry oxygen to all parts of the body. The red blood cells contain a substance called hemoglobin. Hemoglobin helps the cell carry oxygen. When the hemoglobin in the red blood cells is normal, the cells are round. They can bend easily. The cells can move easily through the small blood vessels. The sickle-cell gene causes a change in the hemoglobin. This change can cause the red blood cells to change shape. They look like a farmer's sickle. In this form, red blood cells are stiff. They cannot move easily through the blood vessels in the body.



People with sickle-cell trait, like Mark and Mary, have some sickle hemoglobin in their blood. But they have enough regular hemoglobin to keep them from having medical problems. People with sickle-cell anemia have only sickle hemoglobin in their blood. Even so, they are not sick all the time. While some people with sickle-cell anemia have many medical problems, others have only a few.

Jason's parents first noticed something wrong when he was a baby. Jason's hands and feet would swell up. This was because the sickle cells plugged up the tiny blood vessels. Jason still has pains in his joints sometimes because the blood vessels get plugged. Jason takes aspirin to stop the pain.

He also tires easily, because he has fewer red blood cells to carry oxygen. Red blood cells in a person with sickle-cell anemia live for only about 15 days. Normal red blood cells last for about 120 days.

This doesn't mean that Jason can't do things other students do. He takes gym class and plays just as hard as the other students do. He knows when he's had enough, and he rests when he needs to.

Jason's anemia has slowed his growth. He is a bit smaller than most of the students in the class. But Jason is just as smart as anyone else in the class. In fact, he can explain why he has occasional problems to anyone who is interested. Jason likes to have people ask him directly about his condition. Then he can give them the right information. And maybe they won't make up answers of their own or make fun of him because they don't know what the real problem is.

Jason is a little worried. He is going to a new school. The students and teachers may not know much about sickle-cell anemia. Like all of us, he wants to feel like part of the group. Jason hopes that the people at his new school will understand that he really is no different from anyone else.

Going Further

1. Ask your teacher for illustrations showing dominant, recessive, and X-linked patterns of inheritance. Discuss and practice drawing the patterns.
2. Look in a genetics book for information about some other genetic condition. Find out how often the condition happens. How is it inherited? Can the condition be treated? What are the symptoms? Some of the conditions you might look up are hemophilia, phenylketonuria (PKU), and galactosemia.
3. Females are not usually affected by X-linked recessive conditions. What would the mother's genes have to be in order for a daughter to be affected?
4. Get information about genetic counseling from your teacher and consider the reasons for it. Do you think it is a good idea for people to get genetic counseling?
5. If you wish, write for forms for keeping your own family medical history. You can request these forms from the March of Dimes Birth Defects Foundation. Ask at home if anyone would like to do such a family history.

Self Quiz

1. Why is it important to learn that some medical problems are due to heredity?

Activity 12

FROM ONE GENERATION TO ANOTHER

You talked about how children are like their parents. You used jelly beans to show how genetic information is passed from one generation to another. Your pedigree charts traced a family characteristic through three generations.

Then you discussed the information carried on chromosomes and genes. You saw that dominant and recessive genes cause different patterns of inheritance. After that, you talked about human characteristics that are caused by genes.

Have you begun to wonder how all these ideas are tied together? What can we figure out about all living organisms from the things we have studied so far?

In this activity, you get a chance to use these ideas by "creating" a new kind of creature. You will decide how it will look, how it will move, and what genes it will pass on to its young. Your creature will show what you have learned about why living things stay pretty much the same, generation after generation.

Materials

Creature Cards, Sets A and B
Brads or staples
Scissors

Directions

1. Work in teams of two or three students. Use the Creature Cards in Set A.
2. Spread the cards on the table before you.
3. Think about the creature you would like to make. Think about how its body will look. Will it have four legs or two legs? Will it have scaley skin or feathers? Look at the cards and decide which head, body, legs, and tail might go together. Discuss your ideas with your teammates.
4. Rules for creating your creatures:
   a. Make two creatures—one will stand for a female, one will stand for a male.
   b. Each creature will have four characteristics: head, body, legs, and tail.
   c. Each characteristic in the parents will be the result of two dominant genes or two recessive genes. For example, one may have short ears (SS) and one may have long ears (ss). Or, both creatures may have short ears (SS and SS). You might even have two creatures with long ears (ss and ss). Remember, each characteristic is determined by a separate pair of genes. Do not mix different gene pairs. Match only like characteristics. For example, you cannot cross WW with AA.
   d. Cut out the parts you chose for your creatures. Write the letters for the characteristic on the back. Fasten the parts together with brads or staples.

e. Describe each of your creatures in these charts:

CREATURE I (FEMALE)

BODY PART	GENE PAIR	CHARACTERISTIC SHOWN

CREATURE II (MALE)

BODY PART	GENE PAIR	CHARACTERISTIC SHOWN

5. Now that you have two parent creatures, you can create their young creature. Which characteristics will show up in the young? Think about dominant and recessive genes and how they are inherited.

Use this chart to describe your creature.

YOUNG CREATURE

BODY PART	GENE PAIR	CHARACTERISTIC SHOWN

6. Put your young creature together using the parts in Set B.

7. Show your creatures to your classmates. Discuss why the young creature has body parts like the parents. If the young is not exactly like either parent, tell how the difference happened.

Questions for Discussion I

Write your answers to the following questions. Discuss your answers with your classmates.

1. Your first two creatures were the same kind of animal, but they were not exactly alike? In what ways were they different?

   In what ways were they alike?

2. How did the young creature differ from its father?

   How did it differ from its mother?

3. How was the young creature like its father?

   How was it like its mother?

4. What made the young creature hae some characteristics like each of its parents?

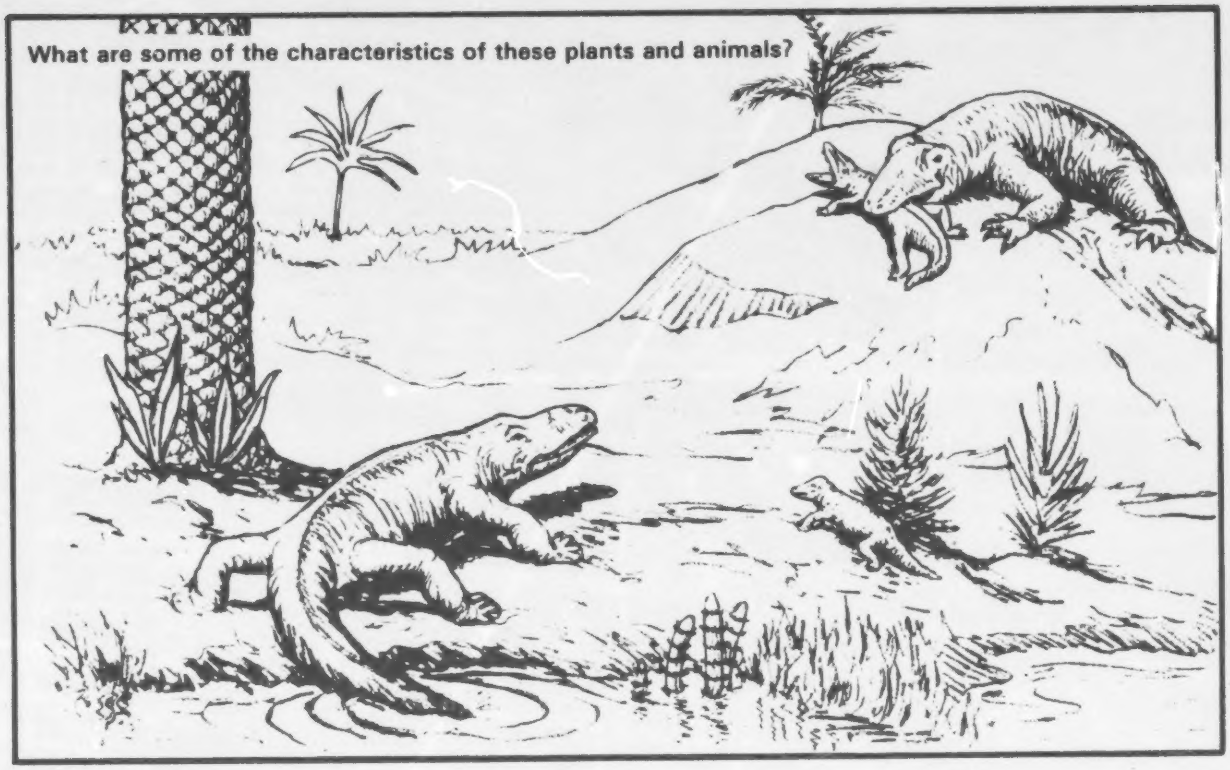
5. Explain the following sentence in your own words. Use the creatures you made, or examples from real life, in your explanation.

   "Kinds of living things remain the same—yet also change—from generation to generation."

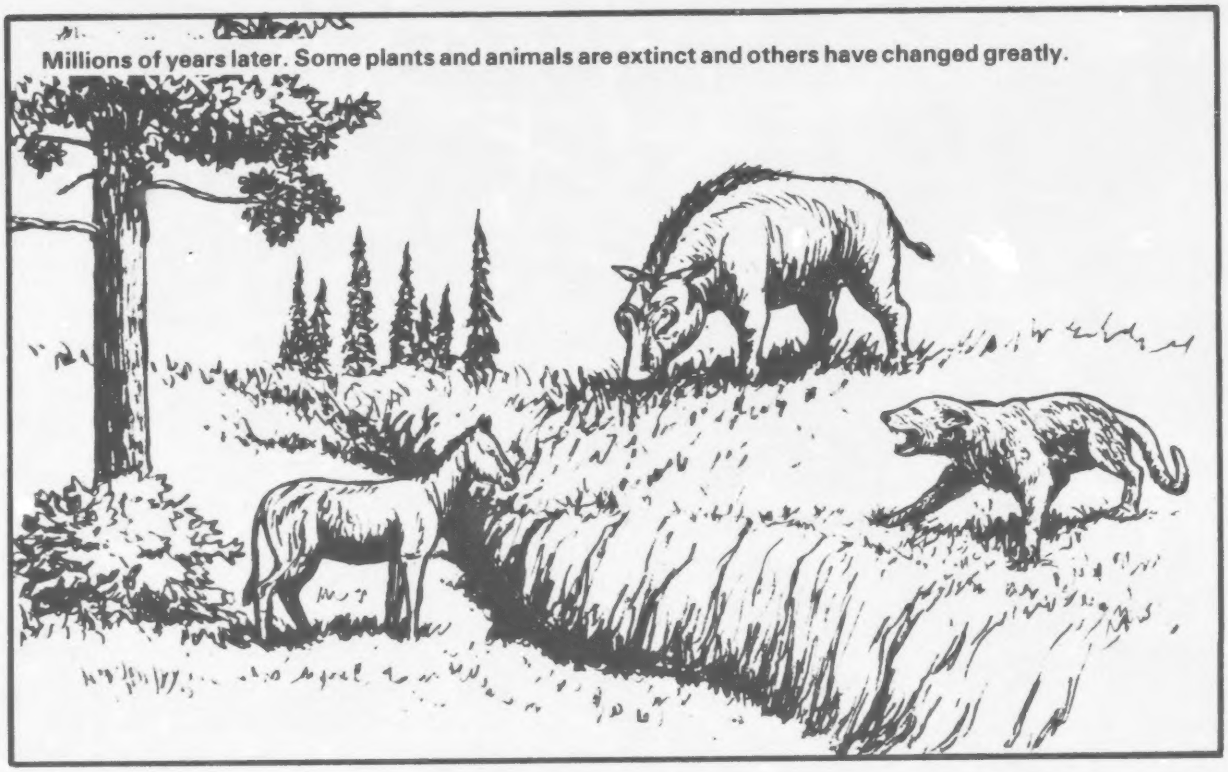
Going Further

1. Use two young creatures to create a third generation. Pay special attention to dominant and recessive genes. Ask your teacher if you need help with this part of the activity.
2. Collect pictures of different generations of plants or animals. Record your observations about how they change and how they remain the same across long spans of time.

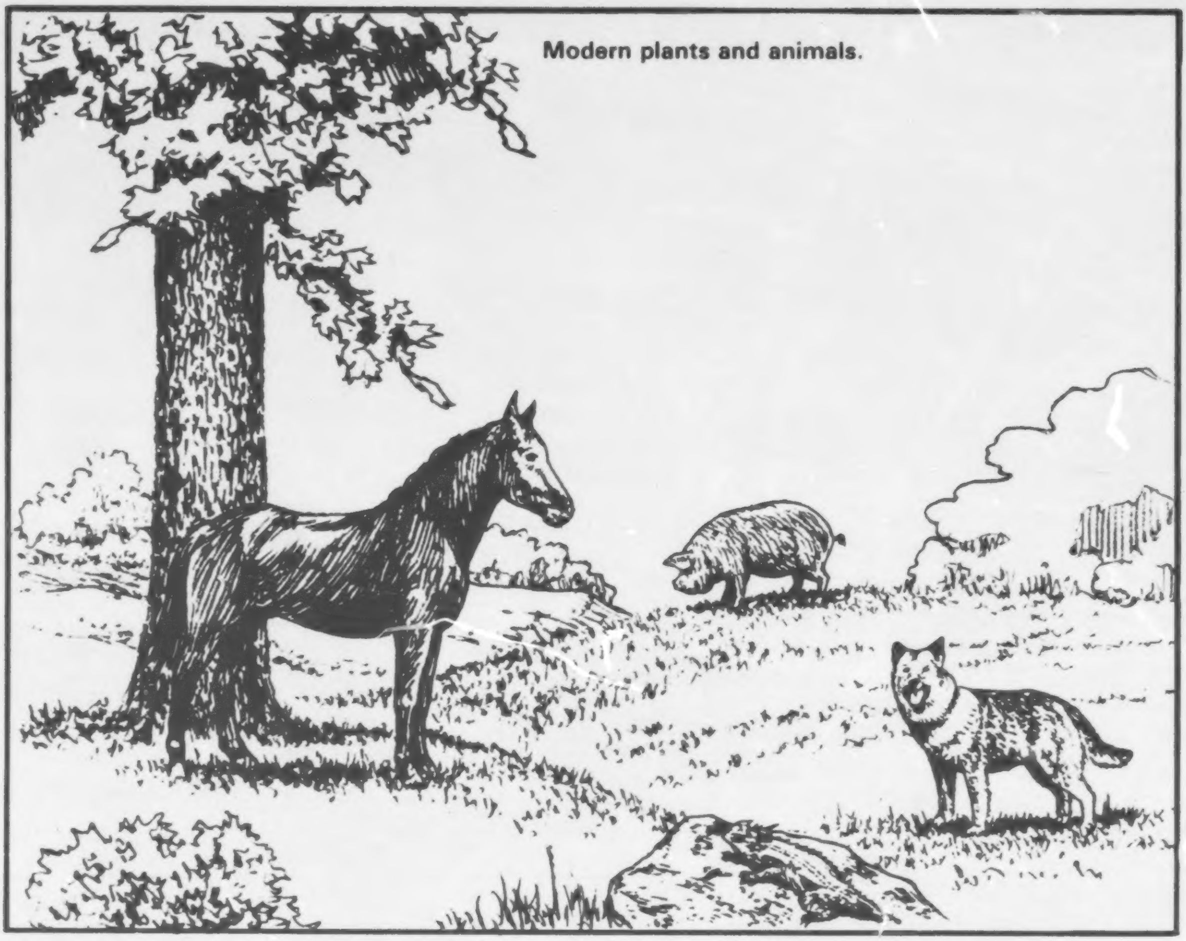
CHANGING GENERATIONS



What are some of the characteristics of these plants and animals?



Millions of years later. Some plants and animals are extinct and others have changed greatly.



Modern plants and animals.

Questions for Discussion II

1. Look at the first and last pictures. Describe some of the changes in the populations of plants and animals.

2. Millions of years passed between the time periods in these pictures. Yet, the trees were still trees and the animals were still animals. How does this happen?

3. Is it possible for changes *not* to happen? Give reasons for your answer.

Self Quiz

1. Why does each kind of plant or animal stay pretty much the same from generation to generation?

SECTION III
VARIETY

ALTHOUGH PEOPLE DIFFER IN
SOME OBVIOUS WAYS,

WE ARE MORE ALIKE
THAN DIFFERENT.

IN WHAT WAYS ARE
PEOPLE ALIKE?

Activity 13

VARIETY IN LIVING THINGS

There are many different kinds of living things. Many kinds of plants and animals can be found in the different parts of the earth. Maybe you have wondered how so many differences happened. In the past, scientists traveled from one part of the world to another looking for and naming these different kinds of organisms.

If you had to rename all the organisms on earth, how would you begin? To which organisms would you give the same name? How would you decide which ones were related to each other? What differences would be important enough to make a new group? What differences would not be great enough? These are the kinds of questions that some scientists spend an entire lifetime trying to answer.

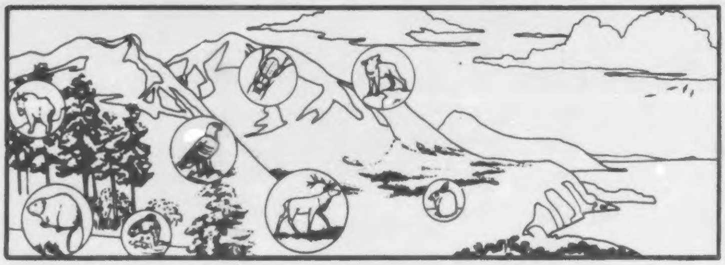
In this activity, you will have a chance to think about the differences among plants and animals. You will have a chance to observe big differences and some differences that cannot be seen easily.

Materials

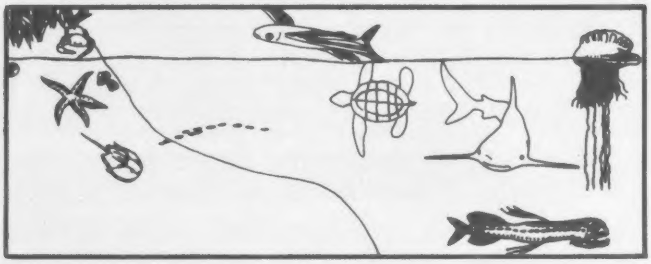
Living Things Card Set
Chromosomes of Living Things Card Set

Directions (Part I)

Look at the following pictures. Read the information about the pictures and answer the questions that follow each one.



On land, living things are found on the highest mountain peaks, more than five miles above sea level.

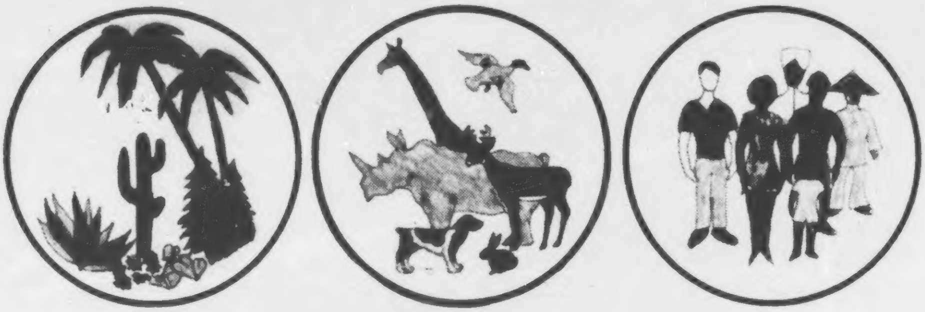


Some organisms live in the deepest oceans, more than seven miles below the surface.

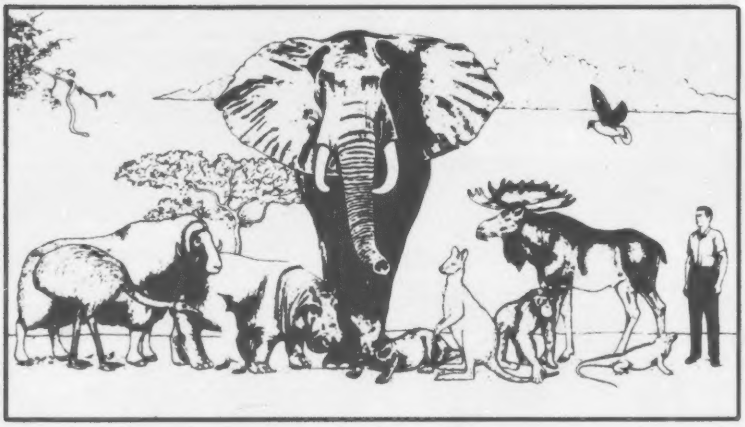
1. Describe four different types of places where different kinds of life could be found. Name some animals or plants that live in each.

2. List how each of these organisms is especially suited for its living place?

More than 4 billion people, nearly one million kinds of animals, and more than 1/4 million kinds of plants live on the earth.



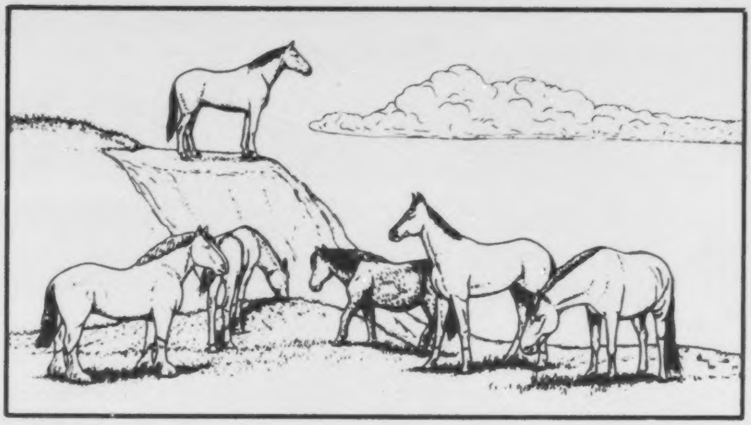
Many individual differences can be found in each group of organisms.



3. How are these animals alike?

How are they different? Do they have different needs? Give examples.

Name two causes of variety among living things?



4. How are these horses alike?

   List three differences.

Directions (Part II)

1. Get the Living Things Card Set from your teacher. Spread the cards on the table before you.
2. Look at the different kinds of organisms. Look at the ways they are alike and the ways they are different.
3. Separate the different kinds of organisms into groups. List the groups below. Beside each group name, write the characteristics that make that group alike.
4. Choose one of your groups. Separate the organisms in that group into *smaller groups.* Look carefully at the ways the organisms are alike and how they are different. Decide which differences are important enough to make a separate group. List your groups below. Beside each group, list the characteristics that make the organisms go together.
5. Get the Chromosomes of Living Things Card Set from your teacher. Spread the cards on the table before you.

   Not all differences among organisms can be seen easily. For instance, there are differences in the genetic material in different organisms. In Activity 7, you studied what a chromosome is and what it looks like.
6. Compare the chromosomes of different organisms. List the similarities and differences. Try grouping organisms by the number of chromosomes each has.
7. Look at the chromosomes of males and females in different species. How are they different?

8. In Activities 5, 9, 10, and 11, you learned some information about genes. Genes are the hereditary messages located on chromosomes. Differences in individual genes also occur among individuals and organisms. Some of these differences cause genetic conditions. With your group, make a list of characteristics you think may be related to differences in particular genes.

9. After you have decided on your groups and have described the important characteristics, return the cards to your teacher. Then answer the Questions for Discussion.

Questions for Discussion

Write your answers to these questions. Then discuss your answers with the class.

1. Do you think variety in environments has anything to do with variety in organisms?

   Give examples of your answer.

2. Could differences in chromosomes be related to differences in organisms?

   How?

3. How many groups did you create from the Living Things Card Set?

   Did chromosome patterns affect your groupings?

Going Further

1. Make a list of variations in organisms or individuals that come about because of environment.
2. Make a list of variations in people that come about because of differences in genes.
3. Describe a medical condition in people that is caused by a difference in chromosomes. Prepare a brief report on this condition.
4. Compare chromosomes in humans and other primate animals. How many differences and how many similarities can you find? Which species look most alike physically and which have chromosomes alike? What might this tell you?
5. Are differences in genes or differences in chromosomes more important among races of people? How about between sexes? Explain your answers.

Self Quiz

1. Explain variation in *different* kinds of living things. Give an example of your answer.

2. Explain variation in the *same* kind of living things. Give an example of your answer.

Activity 14

I AM ME AND YOU ARE YOU

Have you ever thought, "I wish I were like everyone else"? At one time or another, we all worry about how we are different from other people. We worry about looking or acting differently.

In this activity, you will look at some of the differences among the students in your class. You will begin by measuring or observing five human characteristics.

Materials

Metric ruler
Piece of string (25 cm long)

Directions (Part I)

1. Measure the following parts of your body. Record the measurements on the line provided.

   Shoe size: Record the whole number that is closest to your own shoe size. For example, if your size is 6 1/2, write 7; if it is 8 1/2, write 9.

   My shoe size is ________.

   Little finger length: Using the ruler, measure the length of your little finger on your left hand. Measure from the back of your knuckle to the end of your finger, as shown in Figure 8. Do not measure to the end of your fingernail. Round off to the closest whole number, if necessary.

   My little finger length is ________.

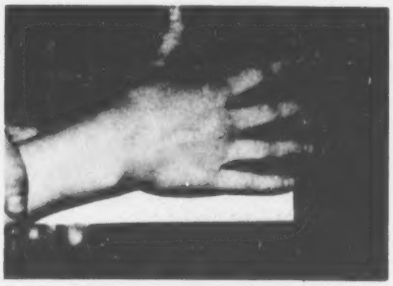


Figure 8.

   Wrist circumference: Wrap the string around your left wrist once. Use a pencil or other marker to mark the distance on the string (Figure 9). Now hold the end of the string even with the end of the ruler. Measure the length of the string to the mark. Round off to the nearest whole number, if necessary.

   My wrist circumference is ________.

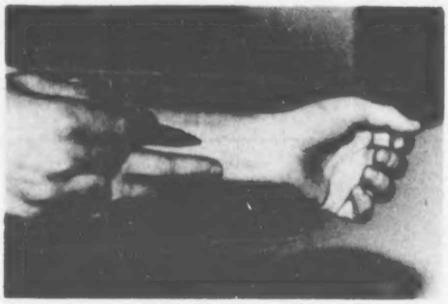


Figure 9.

Pulse rate: Find your pulse on your wrist. Count your pulse for 15 seconds. Use the second hand on the classroom clock or on a wristwatch. If neither of these is available, your teacher will record the time for the class all at once. Multiply your 15-second pulse rate by 4 to get your pulse rate for one minute.

Example: pulse for 15 seconds = 19
x 4
pulse for one minute = 76

My pulse rate is __________.

Sex: My sex is ____ Male ____ Female

Directions (Part II)

Now you are ready to compare the measurements of everyone in your class. Your teacher will collect the data for one characteristic at a time. He or she will record the class information on the chalkboard. Record the data by completing the bar graphs below.

The following example may help you as you begin making your bar graphs. Let's say you begin by collecting the class data on wrist circumference. Your teacher asks everyone who has a wrist circumference of 10 cm to stand, and two students stand up. The teacher records the number 2 under 10 cm on the board.

On your bar graph you would draw a line across the bar for 10 cm, even with the number 2. Color the part of the bar below the line (Figure 10). By reading the bar graph, you now can tell that two students have a wrist circumference of 10 cm.

Collect the data and make bar graphs for all five characteristics. Then answer the Questions for Discussion.

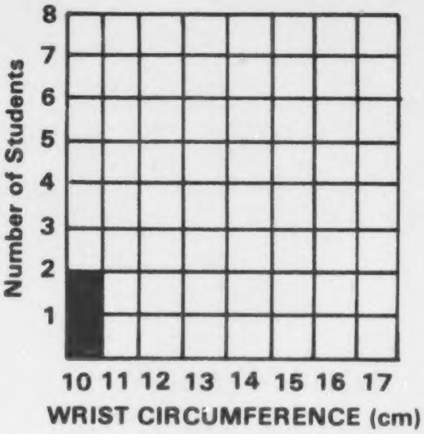
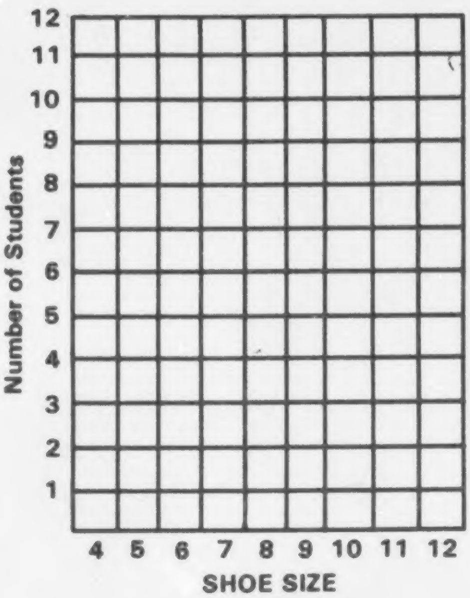
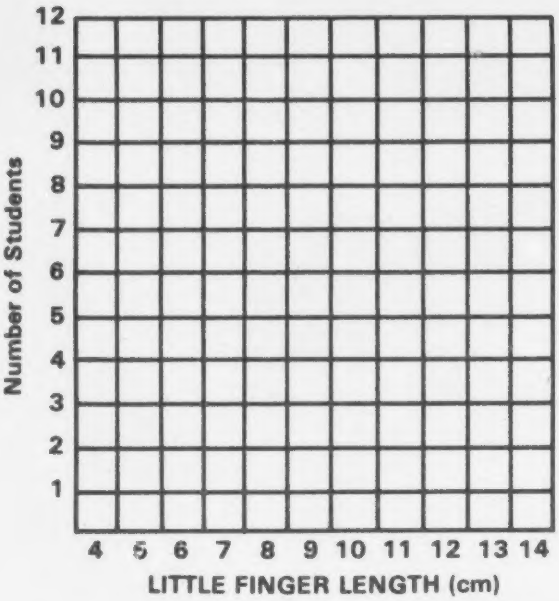
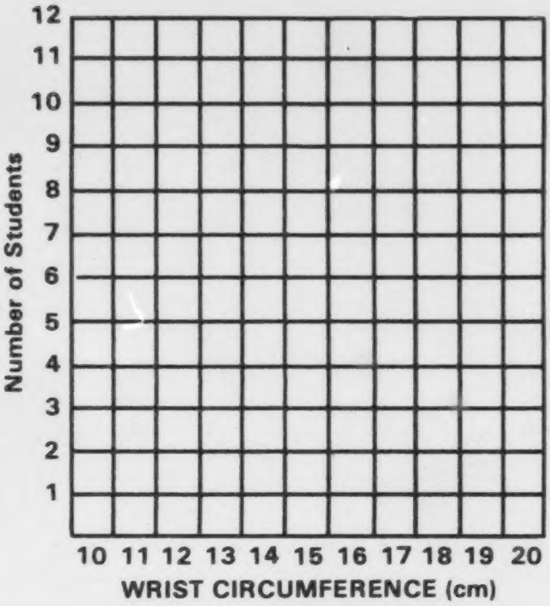
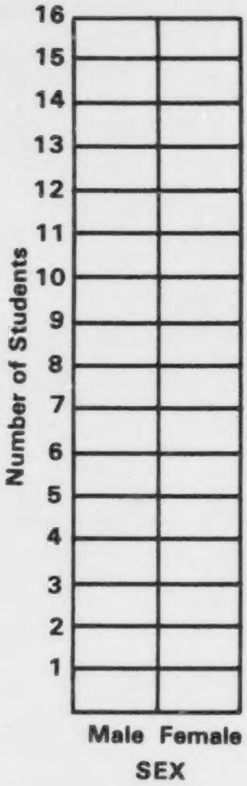


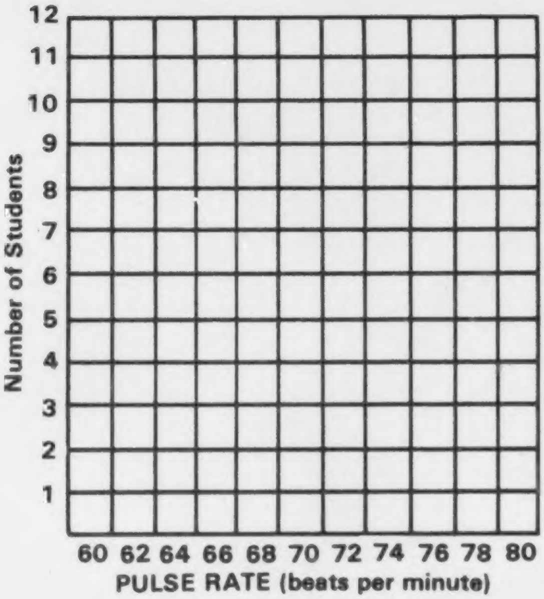
Figure 10.






Number of Students
12
11
10
9
8
7
6
5
4
3
2
1
10 11 12 13 14 15 16 17 18 19 20
WRIST CIRCUMFERENCE (cm)


Number of Students
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
Male
Female
SEX


Number of Students
12
11
10
9
8
7
6
5
4
3
2
1
60 62 64 66 68 70 72 74 76 78 80
PULSE RATE (beats per minute)

Questions for Discussion

Answer these questions. Then discuss your answers with the class.

1. For which characteristics are the people in your class most alike?
2. For which characteristics are they most different?
3. List the characteristics that you think change as people grow older.
4. List the characteristics that you think do not change as people grow older.
5. List the characteristics that you think people can change by doing something different from what they do now.

   Can people change their genetic information?
6. Do members of families have the same growth patterns?

   Why do you think this is so?
7. On each bar graph, put an X at the top of the colored bar where you fit. For example, if your pulse rate is 78, place an X at the top of the bar for 78. How many Xs do you have in each of the following ranges? Compare your numbers with those of other students.

   At the low end ________

   In the middle ________

   At the high end ________
8. Is the rate of change and growth the same for all of your characteristics?
9. Are the people who make up the low bars very different from those who make up the high bars? Explain your answer.

Going Further

1. Why does the sex bar graph have only two bars while the other graphs have several bars? What is the genetic basis for sex differences?
2. What other *genetic* differences can you identify among groups of people? Explain how the environment could modify genetic differences in growth of humans. How much modification can occur.
3. Think about the characteristics you said you could change. What kinds of things might you do to change them?

RUN FOR IT!

"Jeannie is five feet, eight inches. Dot is five feet, ten inches, and Carla is almost *six feet tall,*" Debbie moaned. "How can I get on the same basketball team with those Amazons"?

Debbie was five feet, three and three-eighths inches tall. But she was very quick. And she could dribble the ball and pass it as well as any of the other players. But everyone knew the coach preferred players who were five feet, six inches, or taller.

Nevertheless, Debbie tried out for the team. The coach admitted that Debbie was very good. She asked Debbie to try out again next year, "when you are a little taller." Debbie tried to smile.

"Thank you," she said. "I will try again." But she was terribly disappointed. And just a little angry. So she did what she often did when she wanted to work off her anger. She ran ten laps around the football field behind the school.

"You're pretty good at that," someone said as Debbie halted, panting, beneath the goal posts. Pat Martin walked over to Debbie. Debbie noticed that Pat was only a fraction of an inch taller.

"You ought to be on the track team," Pat continued. "We need more people on the team, and you're a very good runner."

Debbie was too out of breath to answer.

"How about it?" Pat said. "Will you come out for practice tomorrow after school? We sure could use you."

Why not, Debbie thought; it might be fun. She grinned. "Okay," she said, "I'll see you after school."

Self Quiz

1. All people grow and change at the same rate.

____ True

____ False

Activity 15

GENES AND SURROUNDINGS

Genetics is the study of how characteristics are passed from parents to children. Many people think only of genetics and childbirth. This may be because they hear and read a lot about genetic conditions and birth defects.

But genetics is important to everyone, not just to people who are planning families. Your genes will affect your children, but they also will affect you. They will play a very important role in your general health for as long as you live.

Your genes and your environment, together, determine a great many things about you. Because every person has a different combination of genes, the same environment may affect people in different ways.

In this activity, you will see a slide program. The program will show many ways that genes and environment work together.

Directions

1. Watch the slide program your teacher will present.
2. Discuss the Questions for Discussion with the class.

Questions for Discussion

Work with other students to answer these questions. Write your answers in the spaces provided.

1. List as many parts of your environment as you can.

2. Can any parts of your environment be changed? If so, how can that be done?

   Which parts would be easiest to change?

   Which would be most difficult?

3. Can you change your genes?

4. What could you do if your doctor told you your genes made you more likely to get certain allergies?

   to get heart disease?

5. Suppose there is a history in your family of one of the following: heart disease, cancer, diabetes, allergies, asthma, or emphysema. Suppose there is something in your environment that might cause one of these conditions to occur in you. What could you change to avoid becoming ill?

Going Further

1. Contact a regional or local office of the Environmental Protection Agency. Ask for information on things in the environment that may be harmful. Think about your request before you write or call. Ask for specific information.
2. List things in the school environment that might have an effect on your health. Which of these things can you change by yourself? Which can you change as a class? as a student body? Which cannot be changed? Why?
3. Make a list of things in your family environment that might affect your health. Which things can and cannot be changed? Why?
4. Visit the department of health in your community. Does the health department have any public education programs to inform people about medical problems that may be related to genetics and the environment?

Self Quiz

1. Name two things that act together to cause characteristics.

   Which of these can be changed?

   Which cannot?

Activity 16
DECISIONS, DECISION

Have you ever had a hard time deciding what to do? There are lots of different kinds of choices. Everyone makes decisions about things like, "What shall I wear today?" or "Should I have cereal or toast this morning, or should I just skip breakfast?" After you make your decision, you may wonder, "Did I make the right choice?"

Everyone has different decisions to make. And each person has different things to consider when making a decision.

In this activity, you will read about four people and the health decisions they have to make. What are their choices? What things should they consider when they make their choices? Are there right and wrong choices?

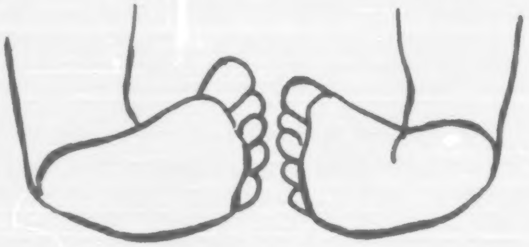
Directions

1. Work in groups of 3 or 4 students. With the others in your group, read the first Decision Problem. Discuss the choices that the person in the story has. Answer the questions at the end of the problem.
2. Continue reading each of the problems and answering the questions. Discuss the choices with the other students in your group. Do you all agree on a "best" choice?
3. When everyone has finished, someone from each group should report the group's decision of a "best" choice to the class. Did each group make the same decisions?

Decision Problem 1

LISA'S FIRST DAY

I was born with club feet. My feet turned in and I couldn't straighten them out. This is a picture of club feet.



Some people only have one club foot; I had two. The bones may be so badly turned that the people have to have surgery. Many times club feet can be straightened with casts or braces. When I was a baby, I had casts. I've seen pictures of them, but I can't remember what it was like to wear them.

The casts didn't get my feet as straight as they should be. Now, I have to wear support shoes. They're awfull What makes me feel worse is that my left leg is an inch shorter than the right one. I have my shoes made so the heel on my left shoe is higher. I wish I could wear shoes like other kids. but, if I do, I walk funny and my feet and legs hurt.

Tomorrow is my first day at Belmont Junior High. I don't want to go. My family moves around a lot because of my dad's job. The last school I went to was terrible! The first day, two girls kept pointing at my feet and laughing. When I was walking down the hall, some guy said, "Look at that girl; she sure walks funny." After a while I made friends, but the hurt didn't go away.

Well, tomorrow's a new start. I wish I knew what to do so the kids wouldn't make fun of me.

Questions for Discussion

1. What should Lisa do to make her first day of school easier? List your suggestions on a separate sheet of paper.
2. Why did you make the suggestions that you did?
3. If you were Lisa, what would you do? How would you feel?

Decision Problem 2

BACK BRACES

"Well, Ted, it's a good thing your school nurse checked your class for scoliosis. Because of the way your bones have formed, your spine is slightly curved. But, since we've discovered it early, we can probably correct the scoliosis with a brace."

Ted's heart sank to his stomach. If only the school had not had scoliosis screening day! Now he was going to have all kinds of trouble. Ted was a little scared. What was scoliosis all about?

The doctor explained that Ted would be wearing a scoliosis brace. The brace is made of leather and has three metal rods, two in the back and one in front. The doctor explained:

"The brace keeps the back straight. You'll have to wear it almost all the time, even when you sleep. But for one hour every day, you can take it off. This will give you a chance to stretch and take a shower. Without the brace, you would develop a hump on your back. Your back would ache and you could develop breathing trouble. As you got older, climbing stairs and even walking would be very painful." The doctor paused to see if Ted had any questions before measuring him for the brace. Ted did:

"Do I have to have any operations?"

"Surgery may be needed if your back doesn't straighten. Wear your brace, and you probably won't need to worry about it."

A week later Ted wore his brace home.

"Do you have to wear that thing? You sure look dumb!" Leave it to a little brother to make you feel worse. Ted looked in the mirror. What a way to start the summer! This thing felt funny and looked strange. Forget tank tops this summer. He'd planned on spending a lot of time at the beach, and now this! He felt miserable. The brace would be hot and itchy; people would stare. His clothes wouldn't fit right, and some of the kids would laugh.

Questions for Discussion

1. What might Ted decide to do? List several choices on a separate sheet of paper. Then list the possible results of each choice.
2. Put the choices in order from the one you think is best to the one you think is worst.
3. What things did you consider when you decided on a "best" choice?

Decision Problem 3

OUT WITH FRIENDS

Cheryl has to be careful about what she eats. She recently found out that she has diabetes mellitis.

People with diabetes have trouble regulating the level of sugar in their bodies. The doctor explained to Cheryl that she would have to balance the food she eats, the amount of insulin she takes, and her level of activity.

If Cheryl gets too much sugar, her body loses water. She gets tired and hungry and she loses weight. The most serious effet is that her body chemistry goes off balance. The levels of acids in her system go up. If she takes too much insulin, her sugar level gets low. She may feel weak, shaky, and sleepy.

If people with diabetes don't watch their sugar levels very carefully, they may have a lot of problems when they're older. They may go blind, have kidney failure, or a heart attack—or all three. It's important that people with diabetes eat regularly, balance their foods, and plan ahead. Cheryl had reviewed all of the doctor's instructions many times. But all of this had happened months ago.

Today, Cheryl couldn't wait for class to be over. After school, she and her friends were planning to see a movie and then stop for pizza. Cheryl was getting hungry. She had stayed up late studying and then overslept this morning. She had skipped breakfast, but she did eat a sandwich for lunch.

The last bell finally rang—school was out! Cheryl and her friends walked to the theater. They stocked up on popcorn, soft drinks, and candy. Cheryl munched on a little popcorn but avoided the sweet foods. After the movie the other kids decided to go bowling next door and to skip the pizza. No one but Cheryl was very hungry after all those snacks.

Questions for Discussion

1. What could Cheryl do? List several choices and the possible results of each choice. Use a separate sheet of paper.
2. Put the choices in order from the one you think is best to the one you think is worst.
3. What things did you consider when you decided on a "best" choice?

Decision Problem 4

"ALAN...!"

My parents are always yelling at me for something.

"Alan, take your feet off the couch." "Alan, close the door." "Alan, take your medicine." And they always try to baby me. All parents do that sometimes, but my parents do it all of the time. It's probably because I have asthma. My folks get upset and think I'm going to die or something when I have an attack.

I know the kinds of things that I can and can't do. Dust, pollen, and animal fur really bother me. Sometimes, when I exercise too much, I have an asthma attack. When I have an attack, it gets hard for me to breathe. I start to wheeze. I get hot and sweaty and turn red. If it's a really bad attack, I have trouble getting any breath. I get pains in my stomach. There is some medication that I can inhale to help me get through the attack. I usually take it wherever I go.

My sister has asthma, too. She doesn't seem to have as much trouble with her asthma as I do. She has only had to go to the clinic once.

I could have fun this weekend. Mike's brother has a farm, and he has invited Mike and me to visit him. Two days without my parents! Mike says we can ride horses, help with the cows, go fishing, and bale hay.

Wow, that sure would be fun! I've never ridden a horse. I've wanted to go with Mike for years, but until now my parents wouldn't let me. I guess they finally realize that I have to learn to make my own choices.

Questions for Discussion

1. What could Alan do? List several choices and the possible results of each choice. Use a separate sheet of paper.
2. Put the choices in order from the one you think is best to the one you think is worst.
3. What things did you consider when you decided on a "best" choice? Were they good or not?
4. What do you think Alan will decide to do?

Going Further

1. Write about one of the hardest decisions that you have had to make. What were your choices? What did you consider when you made your decision? What might have happened if you had made a different choice?
2. Many decisions involve your health. You can choose a life style that will be best for you. Here are some questions to ask yourself:

   Diet: What foods are best for me to eat? What foods should I avoid?

   Exercise: What kind of exercise is good for me? Is there some activity—or inactivity—that I should avoid?

   Sleep: How much sleep is best for me? Does losing sleep make me feel grouchy or bad?

   Other: What other things are good for my body?

   Design a worksheet and record your answers. Have two other people answer the same questions. Write down their answers and compare them to yours.

Self Quiz

1. Describe how decisions may vary with different individuals. Give an example of your answer.

SECTION IV
CHANGE

HOW DO PEOPLE CHANGE AS THEY GROW OLDER?

Activity 17

CHANGE IN LIVING THINGS

Living things around you grow and change. Some "grow up" quickly. Others— people, for example—take a long time to grow up.

Living things can grow in different ways. Think about the ones around you. They can grow in size—a kitten grows into a full-size cat. They can grow in number—a dog may have a litter of puppies. They can grow in age—each of us gets older each day. And organisms also can grow by changing shape—a tadpole becomes a frog.

As living things grow, they pass through a number of stages. And they are always changing.

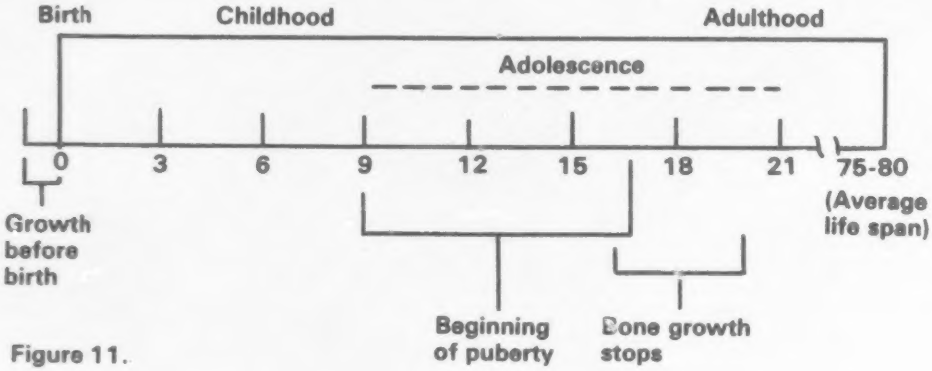


Figure 11.

Figure 11 shows the ages when humans usually begin different stages of growth. This is called a timeline. A timeline is a way to show special events that happen over a period of time. Timelines may cover long periods of time, or they may cover short periods of time. On this timeline, there is not enough room to continue the line all the way to 80 years. The line is broken just before the 75-80 mark to show that there is more time in between.

All people do not grow and develop at the same rate. Therefore, it is hard to say exactly when these stages begin or end. Instead, we can give each stage of growth and development a *range*. For example, a person might begin puberty (sexual maturity) anywhere from age 9 to age 17. That is a range of eight years. Some people begin puberty early and some begin late.

In this activity, you will use timelines to show how different organisms grow.

Materials

Colored pencil
Ruler

Directions

1. Figure 12 shows some stages of growth for five organisms. Following the figure are timelines. You will use the timelines to plot the stages. Three of the organisms are animals. Their timelines will have stages similar to those for humans (Figure 11).

   Plants also have stages of growth. The time from when the seed is planted until it starts to grow is like the "Growth Before Birth" stage for animals. "Starts to Grow" for plants is like "Birth" for animals. "Seed-Bearing Age" is like "Sexual Maturity."

   In the timelines for these organisms, you will use the *average* time when certain stages of growth begin or end. You will not use the range. This will make the timeline easier to draw. Remember, however, that ranges also exist for these organisms. For example, not all mice reach sexual maturity at exactly 35 days.

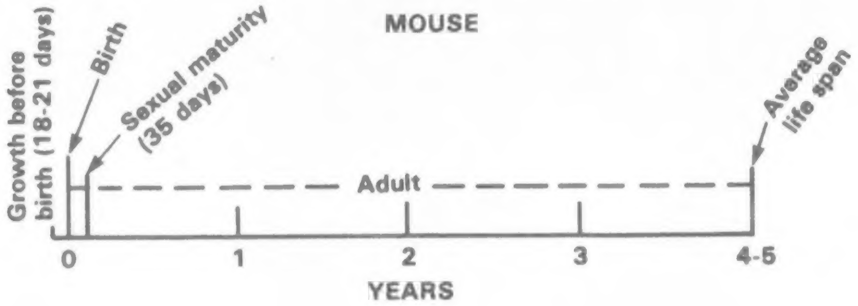
2. Before you begin this work, draw some timelines on the chalkboard. Draw a line to stand for the Average Life Span of a Pea Plant. Below that, draw a line to stand for the Average Life Span of a Giant Redwood Tree. (Your measurements don't have to be exact.) Now, do the same for the Mouse and the Whale. Look at the differences in how long these organisms live. Use Figure 12 to find out how long each of the organisms lives.

ANIMALS	GROWTH BEFORE BIRTH	BIRTH	SEXUAL MATURITY	AVERAGE LIFE SPAN
Mouse	18-21 days	0	35 days	4-5 years
Whale	12-16 months	0	4-5 years	25 years
Cat	60 days	0	10 months	10 years

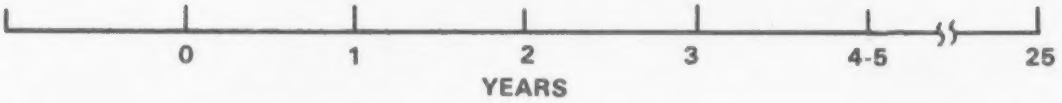
PLANTS	SEED PLANTED	STARTS TO GROW	SEED-BEARING AGE	AVERAGE LIFE SPAN
Pea plant	12 days	0	50 days	5-6 months
Giant redwood tree	28 days	0	40 years	500-1,000 years

Figure 12.

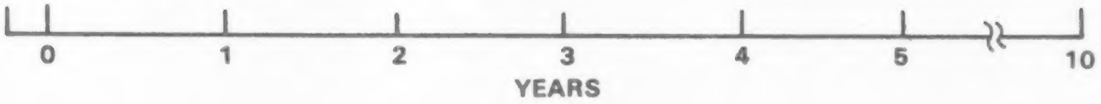
3. The timeline for a Mouse has been completed for you. Fill in the lines for the other four organisms. Notice that a broken line has been used to show that some of the timelines are really much longer than shown. Use the colored pencil and ruler to complete the timelines.



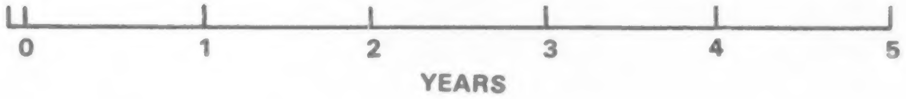
WHALE


0
1
2
3
4-5
25
YEARS

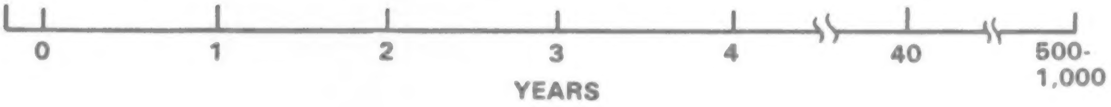
CAT


0
1
2
3
4
5
10
YEARS

PEA PLANT


0
1
2
3
4
5
YEARS

GIANT REDWOOD TREE


0
1
2
3
4
40
500-
1,000
YEARS

GENES AND GROWTH

You have seen that humans go through certain stages of growth. Some people go through the stages more quickly than others. Your genes, often in combination with the environment, determine when you begin certain stages of growth. Your genes also determine when those stages stop. This means that certain genes must "turn on"—or begin working—at the right time. They also must "turn off" at the right time.

Geneticists are scientists who study genetics. They have learned about how certain genes turn on and off at the right time. But there is still a great deal that is not understood. The study of blood is a good example. Blood carries oxygen and other substances to all the cells of your body. The part of the blood cell that carries oxygen is called *hemoglobin* (HEEM uh glow bin).

During growth before birth, one kind of hemoglobin is present. This is called fetal hemoglobin. Fetal hemoglobin is different from the hemoglobin present in the other stages of growth—adult hemoglobin.

Geneticists know that a change to adult hemoglobin takes place shortly after birth. Genes make fetal hemoglobin "turn off" and genes make adult hemoglobin "turn on." No one knows how this happens. Many geneticists are studying how hemoglobin genes and other genes are controlled, that is, how they are switched on and off. Some genes are never turned on again after they are turned off. Other genes are turned on and off many times as a person continues to grow and develop.

Questions for Discussion

Look at your completed timelines. Write your answers to the following questions. Discuss your answers with other students.

1. Do all the living things go through the same stages?
2. Do all of them pass through the stages at the same speed? For example, does the whale pass through the same growth stages at the same age as the mouse does?
3. Look at the timeline for human beings in Figure 11. What stage do you think most of your classmates are in?

   What stage are you in?
4. Do you think all people pass through these stages at the same speed?

   Give an example of your answer.

5. Do you think all mice pass through the mouse timeline at the same speed?

Going Further

1. Look in your school library for information about the growth rate of plants or animals. Make your own chart from the information. Make timelines with the information. Try to find information about things such as fish or birds.
2. Ask your teacher or librarian to help you find information about how organisms have changed since life began on earth.

Self Quiz

1. Different genes are "turned on" during different stages of growth.

_____ True _____ False

2. People grow at the same rate.

_____ True _____ False

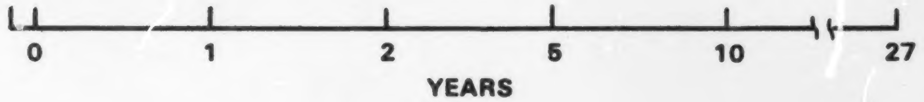
3. Most people go through the same stages of growth.

_____ True _____ False

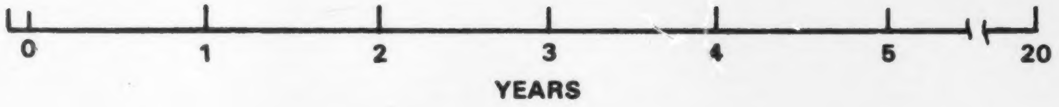
4. Draw timelines for these two different kinds of organisms. Use arrows to show the different stages of growth.

	GROWTH BEFORE BIRTH	BIRTH	SEXUAL MATURITY	AVERAGE LIFE SPAN
SWINE	110 days	0	8 months	27 years
SHEEP	150 days	0	6 months	20 years

SWINE



SHEEP



Activity 18

GROWTH AND CHANGE

How would someone describe you right now—your looks, your interests, your needs? Were you always the way you are now? Will you be this way in the future? In this activity, you can examine some of the ways that humans change during a lifetime.

Directions (Part I)

1. Look at the Human Development pictures on pages 95 and 96. They show the different stages in a human life. The pictures are not in the correct order. Fill in the Human Development chart to show the usual order of a person's development. Start at Number 1 with the first stage. Record the letter of the picture under "Stages in One's Life."
2. How old do you think the person is in each picture? Record your answer on the chart under "Age of Person in Photo."
3. Discuss your Human Development Chart with the rest of the class.

HUMAN DEVELOPMENT CHART

Stages in One's Life	Age of Person in Photo
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	

A

B

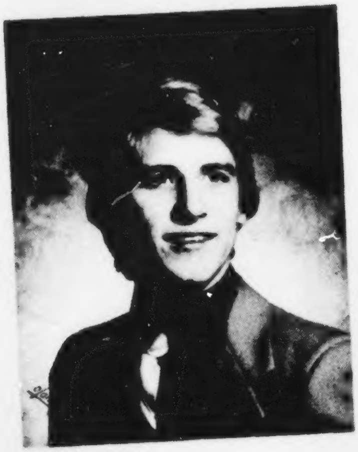
C

D

E

F

G

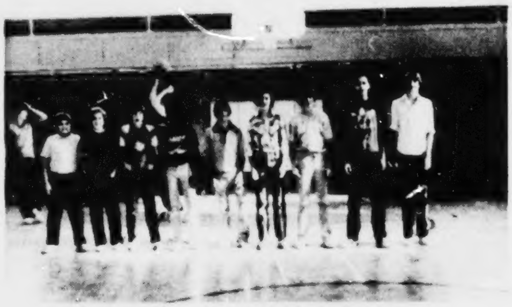


H

Questions for Discussion

Discuss the following questions with your classmates. Write your answer after each question.

1. Describe changes that occur during adolescence.



1. Look at this photo of a ninth-grade gym class. These students were all 14 years old when the picture was taken. How are they alike?

   How are they different?

   Why don't they all look the same?

3. How are people alike in the ways that they change during their lifetimes?

4. How are people different in the ways that they change?

5. Which parts of your development can you control?

6. Which parts of your development are *not* under your control?

7. Do all people grow and develop at the same period? Explain your answer.

Directions (Part II)

Growth is an orderly process. In the first part of this activity, you arranged a series of pictures of a person to show the orderly stages of his life. You could do this even though you had never seen him and knew nothing about him! How were you able to do this? What were the clues that helped you to decide which pictures came first? What factors control the development of all people so that you can predict appearances and even interests and abilities? How much control do individuals have over these processes?

Discuss these questions with the class. Then read the section called "Phases of Human Life" on pages 98 to 100.

Going Further

1. Look in a biology or health book to find out how a person's health needs—such as food or sleep—change as one gets older.
2. Interview several older people. They should be over 65 years old, if possible. Ask them how they have changed through the years. Review your predictions for your own future.
3. Read a biography or autobiography of a famous person. Report on the attitudes, activities, and plans of that person when he or she was a teenager.
4. Observe the development of a chick embryo for ten days and report to the class on your observations. See your teacher for help with the necessary information and materials.

3. Look at your own baby records or talk to someone who has a small child. Make a chart of important stages of early development. Compare your answers with those of other students. Your chart might look something like this.

NAME OF BABY:

Birth weight: **height:**

AGE WHEN

first slept all night: ____________________

rolled over: ____________________

sat up: ____________________

crawled: ____________________

stood alone: ____________________

said word: ____________________

walked alone: ____________________

Self Quiz

1. The amount people grow in their lifetimes varies from person to person.

   ____ True ____ False

2. The speed of growth and development during one's lifetime varies from person to person.

   ____ True ____ False

PHASES OF HUMAN LIFE

Humans are constantly changing. Fat little babies become tall slender adults. People change on the inside as well as on the outside. As people grow and change, their emotions, attitudes, and friendships also change.

A human lifetime can be divided into several periods of time: prenatal life, infancy, childhood, adolescence, adulthood, and old age. (Prenatal means "before birth.") You can see all of these periods, or phases, of human life if you look around you at people of all ages.

Let's look more closely at these phases.

Prenatal Life

During prenatal life, growth is more rapid than in any other phase of human life. The fetus develops completely in about nine months. It starts off smaller than the period at the end of this sentence and ends up weighing 2 1/2 to 4 kilograms and measuring about 47 to 53 centimeters long.

The developing fetus is totally dependent on its mother. The fetus receives food and oxygen from the mother through the placenta and the umbilical cord. The umbilical cord also carries away wastes.

An amazing thing happens during prenatal life. A single fertilized egg cell develops into all the different body parts. This all takes place because of the "instructions" in the single fertilized cell. All the cells in the developing fetus have the same genes. But only certain ones are "turned on" in certain cells. Some cells develop into heart cells, some into brain cells, some into bone cells, and so on. Scientists do not know how the body tells only certain genes in a cell to "turn on."

Cells grow in two ways—they increase in number and they increase in size. Both kinds of growth are under the control of genes. Sometimes things go wrong that cause changes in the genes. These changes can affect the way some cells form an eye, or a brain, or some other body part. Some things that affect the mother also may affect the fetus. Infections in the mother sometimes hurt the developing fetus. Too much alcohol, smoking, and many other things in the mother's environment also may hurt the fetus.

Some organs (such as the eyes) are almost completely developed by the time of birth. Others, such as the brain and nervous system, continue to grow and become more complex long after birth.

The changes that take place during birth are very important. The baby leaves the environment that has provided food, oxygen, and protection. It must now begin to breathe and take food for itself. The baby's body must be able to control its own temperature, fight off infection, and get rid of waste products. All of these abilities are "pre-programmed" in the baby's genetic makeup. They are ready to turn on at just the right time.

Infancy

Marcie Durant is 18 months old. She is in the phase of life called infancy. Marcie is plump and has dark brown hair and brown eyes. She learned to recognize special people when she was only one or two months old. She reached for objects and held onto them when she was three months old. At six months, Marcie could sit up. She crawled all over the house and got into everything when she was about nine months old. By the time Marcie was 14 months old, she was walking.

Marcie's family recognizes her as a person because she has her own special personality, even at this early age. She lets people around her know what she likes and what she doesn't like. She is beginning to say words that let her family know what she wants.

Childhood

Marcie has an older brother, Bart. Bart is in the phase of life called childhood. This phase begins at about age 2. Bart is now five years old. He likes to play with Marcie, but sometimes he is jealous because Marcie seems to get more attention than he does. Bart is beginning to do some things on his own. He doesn't always need to have his mother or father around him. He rides his tricycle around the block and plays in the neighborhood park with his friends. Bart also likes to pretend. He has a special make-believe friend whose name is Oliver. Oliver helps Bart solve problems.

Bart will be in the childhood phase until he is about ten years old. He has grown a lot since he was two years old. His arms and legs are longer and thinner than they were then. And his brain is growing. He can solve problems and make sentences. He knows thousands of words. By the time Bart is ten years old, he will have learned a lot. And he will be able to use what he has learned in many different ways.

Adolescence

Joanne lives next door to the Durant family. Sometimes she babysits with Bart and Marcie. Joanne is 14 years old and is in the phase of life called adolescence. She has lots of friends, both girls and boys.

Joanne is much taller than her best girlfriend, Pat. She is even taller than most of the boys her age. Joanne has not developed the body shape of an adult female yet. But her friend, Pat, is beginning to look like a woman. Pat has begun her menstrual cycle and is beginning to develop breasts. She is also beginning to add a small amount of fat to her body that makes her look rounder than she used to. Both Joanne and Pat are looking forward to becoming adult women.

Both girls enjoy spending time with their friends. They are growing and changing. And they are learning how to get along with other people. Girls tend to mature somewhat earlier than boys. The period of adolescence in girls runs from age 10 to age 18. In boys, it runs from about age 12 to age 20. Joanne and Pat will begin the adult phase of life when they are about 18 years old.

Adulthood

Ann is Marcie's and Bart's mother. She is in the longest phase of human life—adulthood. Both Ann and her husband, Wayne, work. But they work different shifts, so one of them is always home to take care of Marcie and Bart. Ann and Wayne share the housework and have a big garden. Bart helps plant seeds and pull weeds in the garden. Ann likes to play tennis and Wayne is on a softball team. Sometimes the whole family goes camping and fishing. Sometimes Ann and Wayne go cross-country skiing for a weekend and Joanne stays with Marcie and Bart.

Ann and Wayne have grown as tall as they ever will. Both are in their reproductive years; that is, they are capable of being parents. This biological capability developed in their adolescent years and will continue throughout much of their adulthood. Wayne will maintain his reproductive capability throughout life, but Ann will lose the ability to become pregnant when she goes through *menopause,* probably in her forties or fifties. Ann and Wayne were biologically capable of being parents when they were teenagers, but both are glad they waited until they were adults to have children. Adulthood brings with it maturity and greater ability to handle problems and assume responsibilities than adolescents typically have.

Ann and Wayne are "grown-up," but that doesn't mean they do not change anymore. Both of them are changing in their interests, attitudes, knowledge and views of life, even as their bodies are aging every day. When Marcie is old enough to go to school, Ann also wants to go to school. She wants to get a college degree in computer science. Wayne is thinking of starting a business of his own. As they and their children grow older, other changes will take place in their lives.

Old Age

Mr. Jones is Marcie's and Bart's grandfather. He is Ann's father. Mr. Jones is 83 years old and lives on a farm. He is still quite active. He manages two small farms, mostly by using his telephone. Mr. Jones is in the phase of life called old age. He is having a little trouble hearing, and he can be quite cranky sometimes. His main physical problems are that his feet hurt when he walks a lot, and he has more difficulty getting his breath than he did when he was younger. Sometimes he gets unhappy because he has to slow down his activities. But his entire family depends on him for advice and understanding. Everyone tells him that slowing down a little doesn't matter. He's still a very important person in their lives.

Activity 19
GROWING UP, GROWING OLDER

Diane Markum is a research scientist. She is conducting a study. For part of the study, she interviews people in their thirties. She asks them how they felt about themselves when they were teenagers.

Recently, she talked to Melissa Hill. Melissa is 35 years old. She is the mother of two children, ages 9 and 11. She works all day in an office and takes classes in the evenings at a local college. She loves her family, her work, and her school.

Melissa looks about the same as other women her age. She is a bit taller than "average" and a little heavier. But you wouldn't really notice her in a crowd. Things were very different when she was younger. Here's what Melissa had to say about her teenage years:

"When I was 13, I felt like some kind of circus freak. I was the shortest kid in my class, and I was very overweight. I felt fat, short, and unattractive. I had not developed the body shape of a woman like some of my friends had. I thought I would never have a waistline! I was shy and awkward. I would sometimes go to my room and cry because I felt so ugly.

"Gradually, things got better. I was still the shortest girl in my ninth grade class. But by the end of the tenth grade, I was one of the tallest. I didn't lose any weight, but I didn't gain any, either. After I grew taller, I wasn't as fat as I had thought I was. I got some new clothes. They fit like they should, and I felt like I looked a lot better. By the time I was 17, I had nearly forgotten how awful I felt when I was 13.

"I still feel shy and clumsy sometimes, even now. I think I worry more than I should about my weight. But, all in all, I survived growing up."

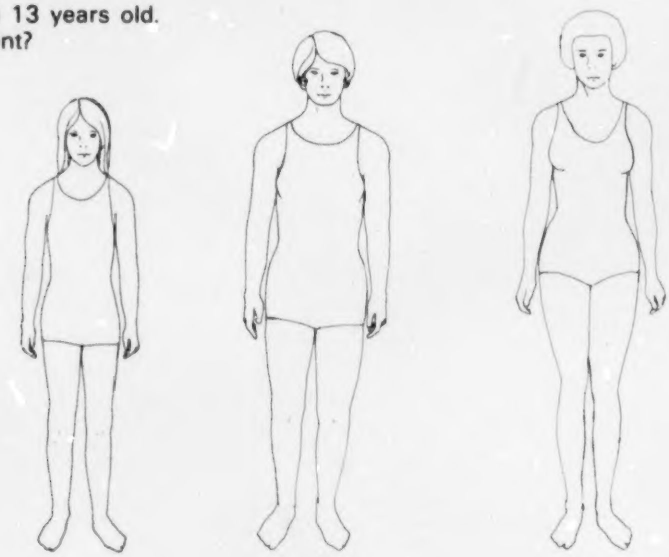
Of course, not everyone feels as badly in their teen years as Melissa did. Not everyone grows a lot in one year, or changes from the shortest to one of the tallest. But everyone has a unique story about her or his growth. A lot of people feel that there is something wrong with the way they are growing. They feel they are too short, too tall, too fat, too thin, too immature, or too mature. Actually, none of these things is true.

In this activity, you will see how six young people grew. Their rates of growth were very different. Yet each growth pattern was perfectly normal and healthy. You will see how their heights changed from the time they were 11 until they were 18. You will use that information to learn about how different people grow.

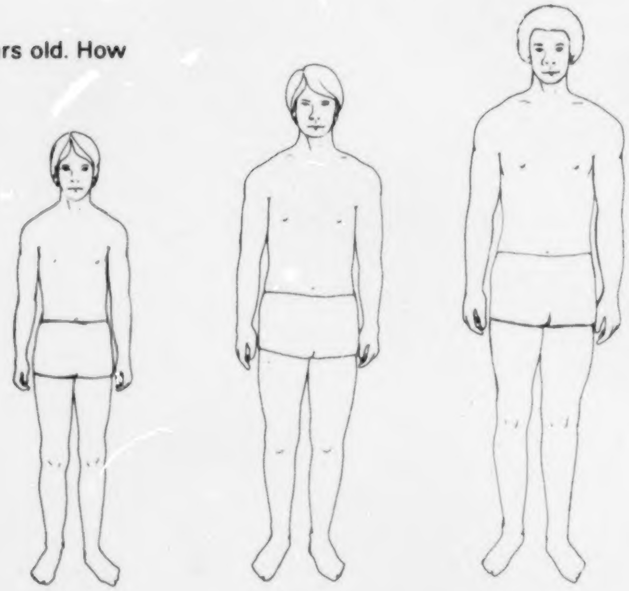
Directions (Part I)

1. Work in teams of two or three students. Begin by answering these questions. List as many ideas as you can.

Ann, Peggy, and Maria are 13 years old. How are their bodies different?


ANN
PEGGY
MARIA

Joe, Frank, and Ted are 15 years old. How are their bodies different?


JOE
FRANK
TED

2. Look at the bar graphs on pages 104 and 105. Ages are listed across the bottom of each graph. The numbers for height are along the left side. Look at the bars for the girls' heights at age 11. Can you see that a short mark was drawn on the graph line opposite the number for the three different heights: Ann, 133; Peggy, 140; and Maria, 150? Lines drawn from the marks to the bottom of the graph form the bars.

The curved lines on the graphs connect dots that show the *average* of the three measurements at each age level.

Listed below are the heights (in centimeters) for each of the girls and boys from age 11 to age 18. The bars for ages 11 and 18 are already drawn on the graphs. Complete the graphs by drawing the bars for the ages in between. Use colored pencils to represent the different boys and girls.

GIRLS' AGES	11	12	13	14	15	16	17	18
ANN	133	135	139	145	151	153	155	156
PEGGY	150	157	164	167	168	169	169	169
MARIA	140	149	156	163	166	169	172	172

HEIGHT (in cm)

BOYS' AGES	11	12	13	14	15	16	17	18
JOE	131	136	144	150	158	166	173	175
FRANK	146	152	160	166	175	181	182	182
TED	140	146	153	162	169	170	171	171

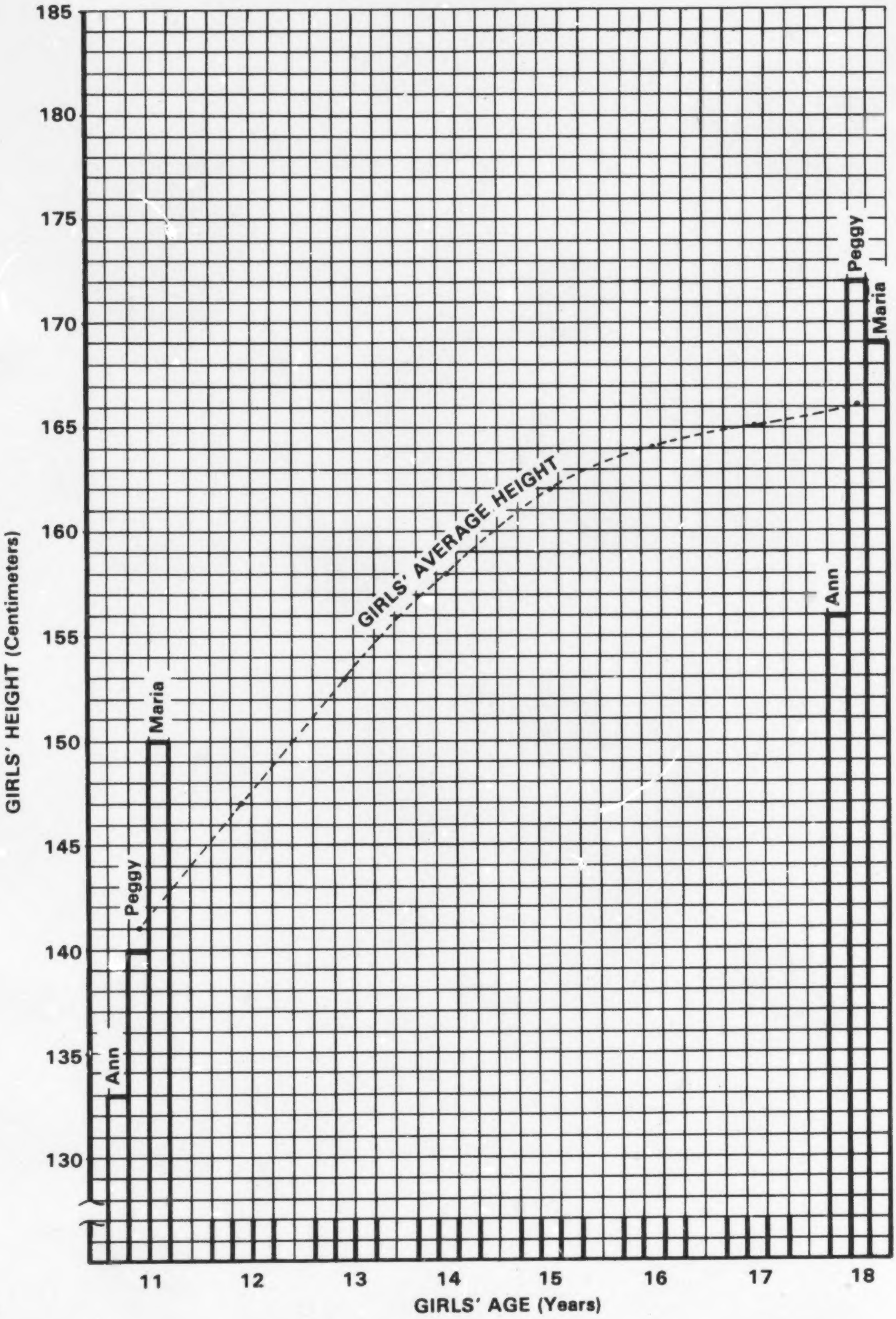
HEIGHT (in cm)

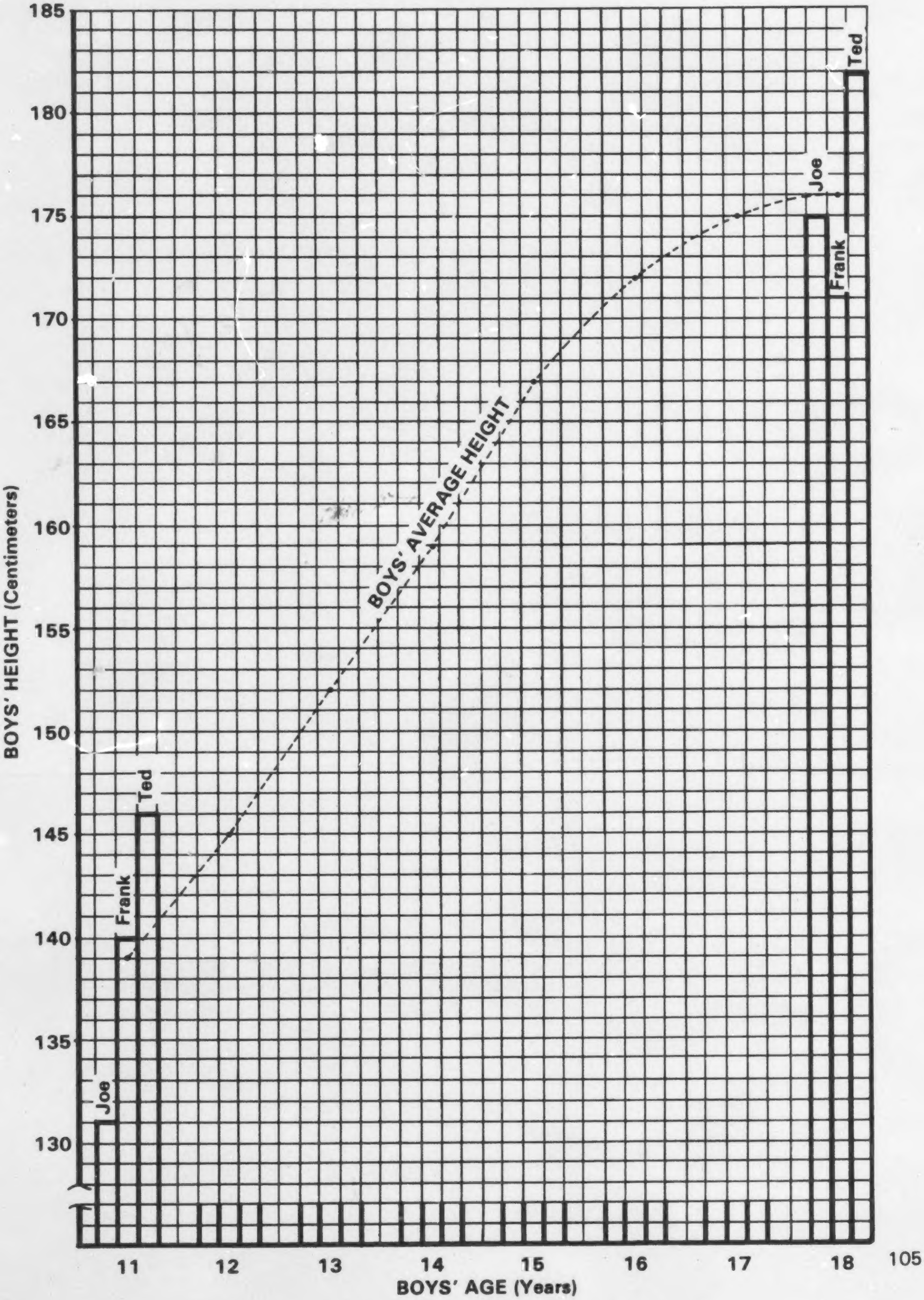
Questions for Discussion I

After you have completed the bar graphs, answer these questions.

1. Which girl had almost finished growing by the time she was 14?

   Which boy had almost finished growing by the time he was 15?


185
180
175
170
165
160
155
150
145
140
135
130
GIRLS' HEIGHT (Centimeters)
Ann
Peggy
Maria
GIRLS' AVERAGE HEIGHT
Ann
Peggy
Maria
11
12
13
14
15
16
17
18
GIRLS' AGE (Years)


185
180
175
170
165
160
155
150
145
140
135
130
BOYS' HEIGHT (Centimeters)
Joe
Frank
Ted
BOYS' AVERAGE HEIGHT
Joe
Frank
Ted
11
12
13
14
15
16
17
18
BOYS' AGE (Years)

105

Which boy grew the most after his 16th birthday?

Which girl grew the most between ages 12 and 14?

2. At age 18, Maria was shorter than Peggy was at age 18. But when Maria was 11 she was taller than Peggy was at age 11. Was there any shift like this among the boys? Explain.

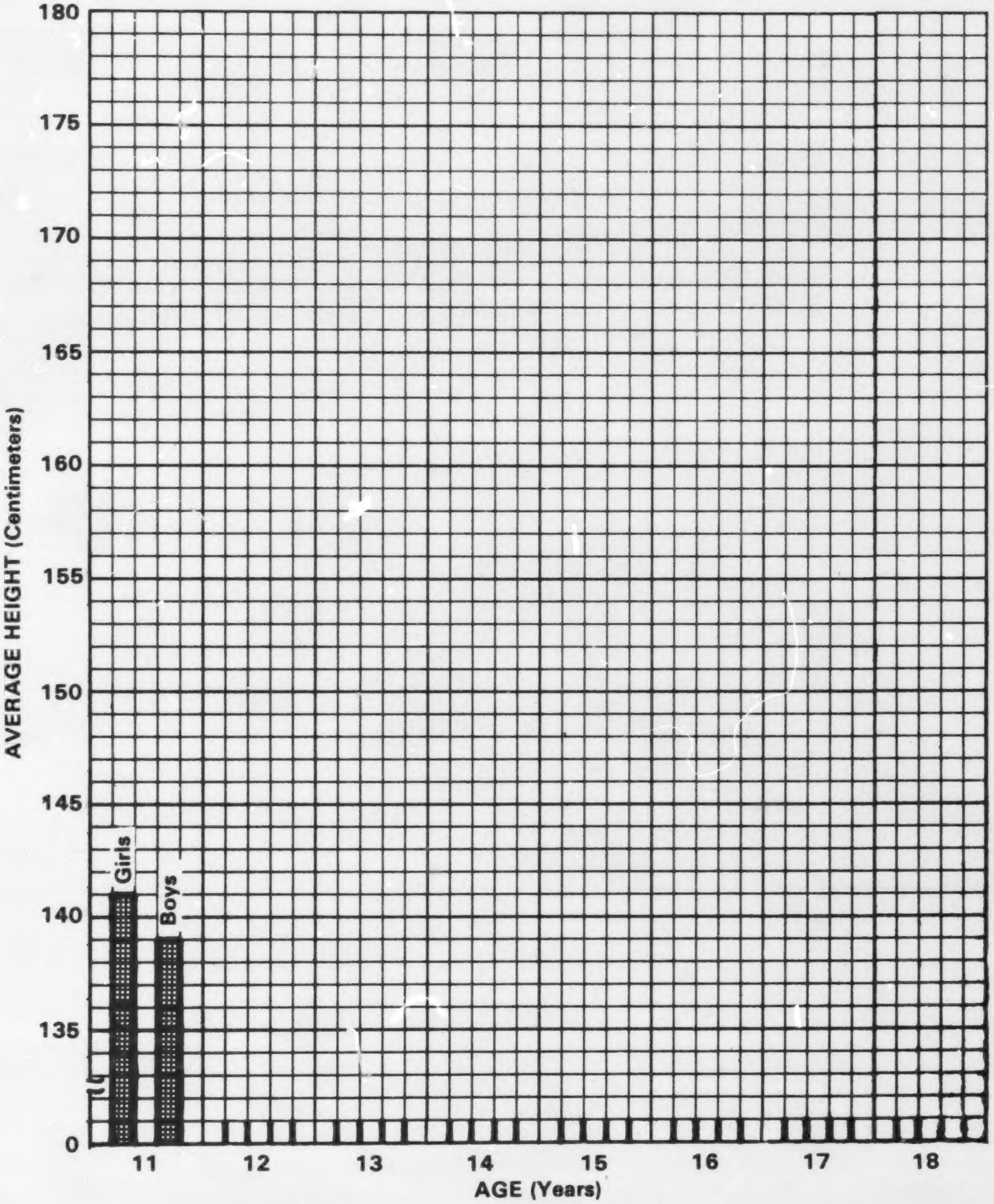
3. What is meant by "average height"? (Look at the line drawn on each graph.) How was the average determined? Were any of these people ever exactly average?

Directions (Part II)

1. Use the data below to make a graph of the average heights of the three girls and of the three boys. Make your graph in the space provided. Use two colored pencils to represent data for the girls and the boys.

AVERAGE HEIGHT—GIRLS	
AGE	HEIGHT
11	141
12	147
13	153
14	158
15	162
16	164
17	165
18	166

AVERAGE HEIGHT—BOYS	
AGE	HEIGHT
11	139
12	145
13	153
14	159
15	167
16	172
17	175
18	176



Compare the average heights for the boys and the girls at age 11; at age 15; at age 16. What happened? Use examples from the first bar graphs you made to explain your answer.

Directions (Part III)

Very young children grow very fast. An average baby is between 50 and 60 centimeters tall when it is born. The child may double its height by the time it is four years old. Between ages 4 and 5, the average child grows about 6 centimeters. Between ages 5 and 6, ages 6 and 7, and ages 7 and 8, it will grow at a slightly slower rate.

1. Look at the Boys' Growth Table below. The table shows the heights of three boys from age 8 to age 18.

BOYS' GROWTH TABLE (Height in cm)

AGE	8	9	10	11	12	13	14	15	16	17	18
Arthur	118	122	126	131	136	141	147	155	165	173	174
Kevin	126	131	136	140	146	153	162	169	174	176	176
Jess	132	138	143	148	153	159	166	175	181	182	183

You can make growth rate curves for the heights of these boys by plotting the number of centimeters they grew each year on the graphs on page 141. Kevin's rate of growth has been plotted for you on the graph at the top of the page.

2. To see how this was done, look at the information about Kevin in the Boys' Growth Table. The first point on the Boys' Graph is the number of centimeters that Kevin grew between ages 8 and 9. 131—126 = 5 cm. The second point is the number of centimeters that he grew between ages 9 and 10. 136—131 = 5 cm. The third point is the number of centimeters that he grew between ages 10 and 11. 140—136 = 4 cm. The line that connects the points is the growth rate curve for Kevin.

   At the 10-11 point, the curve dips down because Kevin grew at a slower rate during that year than he did in the two years before. When the line is rising, Kevin's growth rate is speeding up. When the line is falling, Kevin's growth rate is slowing down. Kevin's growth began to speed up when he was about 11. It began to slow down after age 14. By age 17, Kevin's growth was complete, and his growth rate was 0.

   The dotted line on Kevin's graph is the average growth rate curve for boys. How close was Kevin's growth rate curve to the average?

3. Use the two blank graphs on page 109 to plot the growth rate curves for Arthur and Jess.
4. Now look at the Girls' Growth Table below and the Girls' Graph at the top of page 110. Rachel's growth rate is plotted on this graph. The dotted line on this graph is the average growth rate curve for girls. Rachel's growth began to increase at age 11. At age 16, she stopped growing taller, and her growth rate was 0.
5. Plot the growth rate curves for the other two girls on the graphs at the bottom of page 110.

GIRLS' GROWTH TABLE (Height in cm)

AGE	8	9	10	11	12	13	14	15	16	17	18
Amy	118	124	129	133	136	140	146	154	157	158	158
Rachel	124	130	135	140	149	156	161	165	167	167	167
Gail	127	133	139	150	157	163	167	169	170	170	170

Questions for Discussion III

1. At what age did Rachel have her highest growth rate?
2. Was Kevin growing faster or slower at age 17 than he was at age 16?
3. How do the growth curves for the girls differ from the growth curves for the boys?

Going Further

1. Write a story about one of the young people in this activity. Describe how he or she grew. Describe how that person might have felt about growing up and becoming older.
2. Interview one of your parents or another adult that you know very well. Ask that person how he or she felt about growing up.

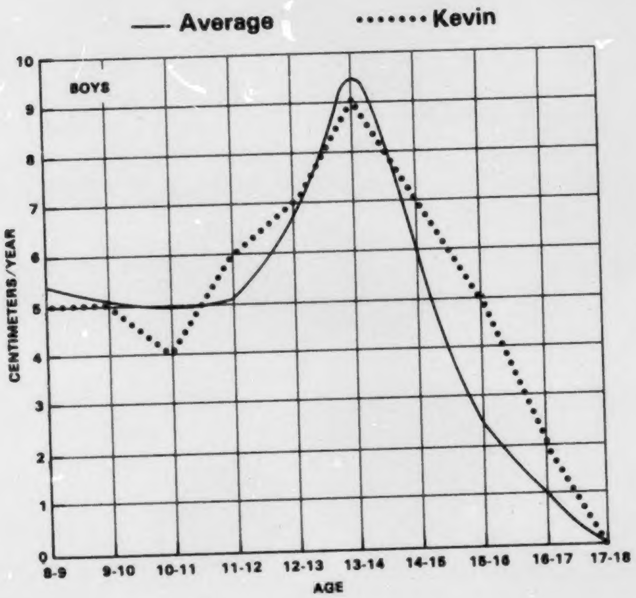
Self Quiz

1. Which group of adolescents usually reaches the peak of growth earlier?

    ____ Girls   ____ Boys

2. All boys grow at the same rate.

    ____ True   ____ False


— Average
•••••• Kevin
BOYS
CENTIMETERS/YEAR
0
1
2
3
4
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6
7
8
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10
8-9
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10-11
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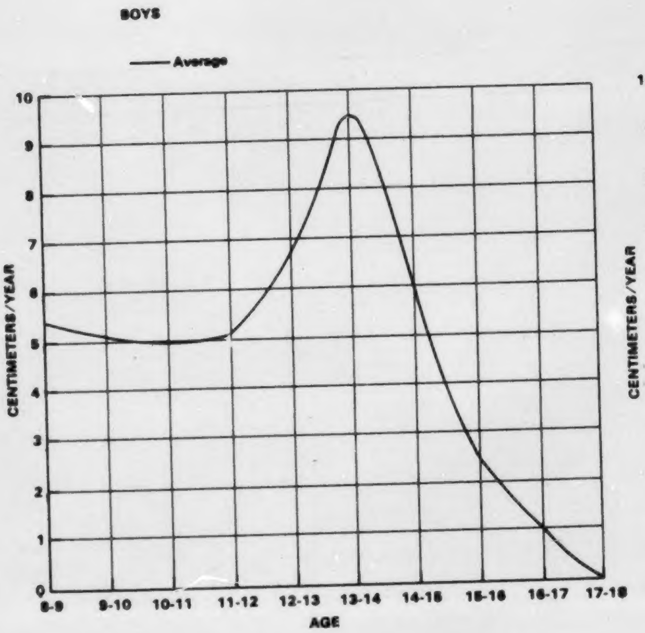
14-15
15-16
16-17
17-18
AGE


BOYS
— Average
CENTIMETERS/YEAR
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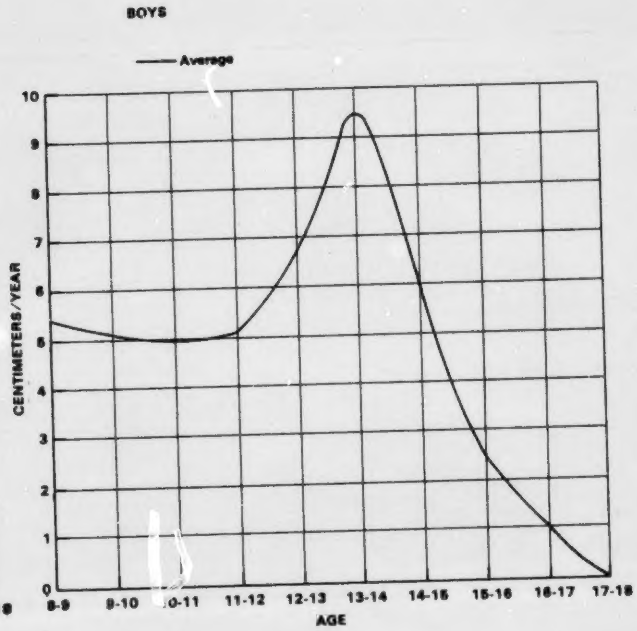
17-18
AGE


BOYS
— Average
CENTIMETERS/YEAR
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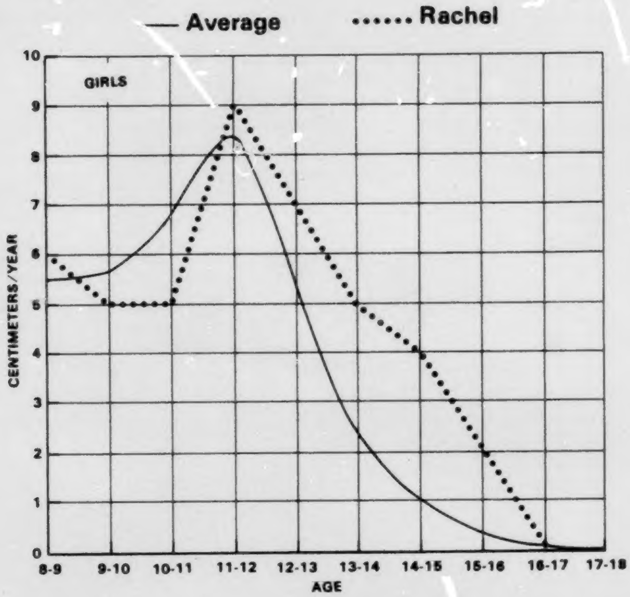
15-16
16-17
17-18
AGE


— Average
...... Rachel
GIRLS
CENTIMETERS/YEAR
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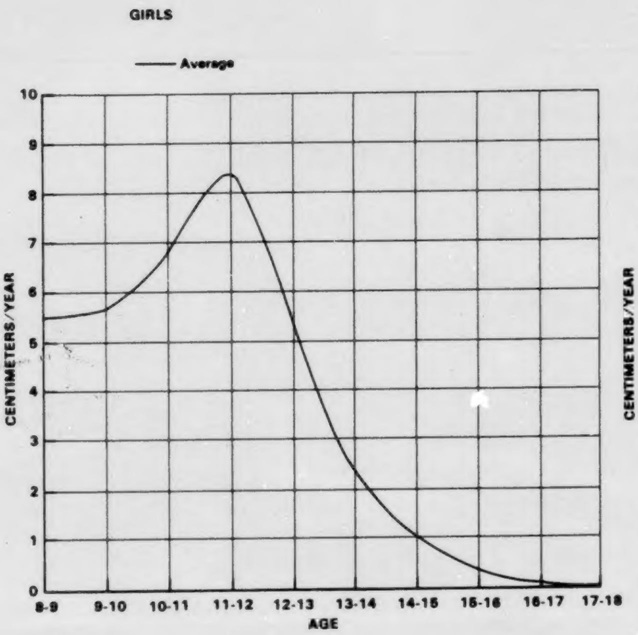
15-16
16-17
17-18
AGE


GIRLS
— Average
CENTIMETERS/YEAR
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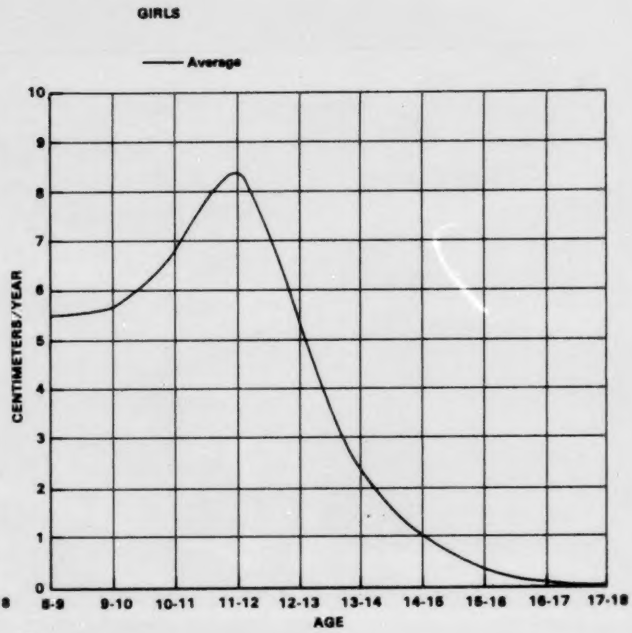
14-15
15-16
16-17
17-18
AGE


GIRLS
— Average
CENTIMETERS/YEAR
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8-9
9-10
10-11
11-12
12-13
13-14
14-15
15-16
16-17
17-18
AGE

Activity 20

DIFFERENT KINDS OF GROWTH

At some time, you've probably thought about what you were like when you were a baby. And you probably have thought about how you want to be when you are an adult. Everyone grows from child to adult and goes through many changes as this happens.

In this activity, you will have a chance to think about other kinds of growth. You will also have a chance to think about the kinds of changes people go through as they grow.

Materials

Growing Pictures
Scissors

Directions

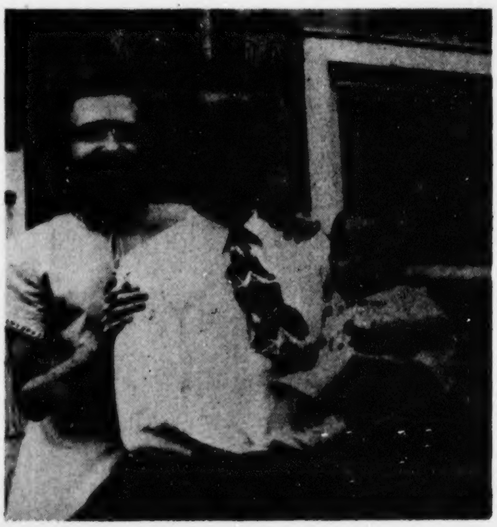
1. Read "The Growing Adventure" on pages 118 to 122. After you finish reading, think about the different ways of growing.
2. Cut apart the Growing Pictures on pages 113 and 115. Spread them on the table before you. These pictures show how one boy grew and changed.
3. Look at each picture. Place the pictures in order, from when the boy was youngest to when he was oldest.
4. Check your order to see if it is correct. Your teacher can help you.
5. With the pictures in order (youngest to oldest), look at how this person changed as he grew.
6. List the ways you think he changed. Give examples of your answers.

Questions for Discussion

Write your answers for these questions. Discuss your answers with your classmates.

1. Look at this picture. How are the mother and boy alike?

   How are they different?



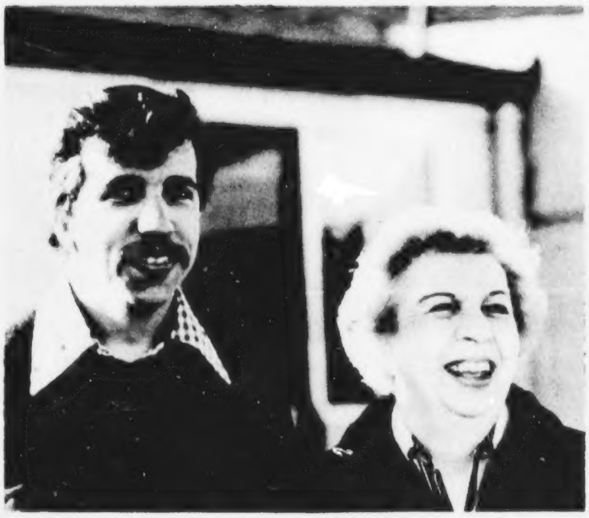
V W

Y U

Z S

T X

2. The boy has now grown into a man. How are the mother and son alike?



How are they different?

3. List four kinds of growing. Give examples of your answers.

4. Name two different ways people can be growing at the same time. Give an example of your answer.

5. What do you think are some reasons that growing occurs? List your reason in one column and the reasons your classmates give in another column.

MY REASONS	MY CLASSMATES' REASONS

THE GROWING ADVENTURE

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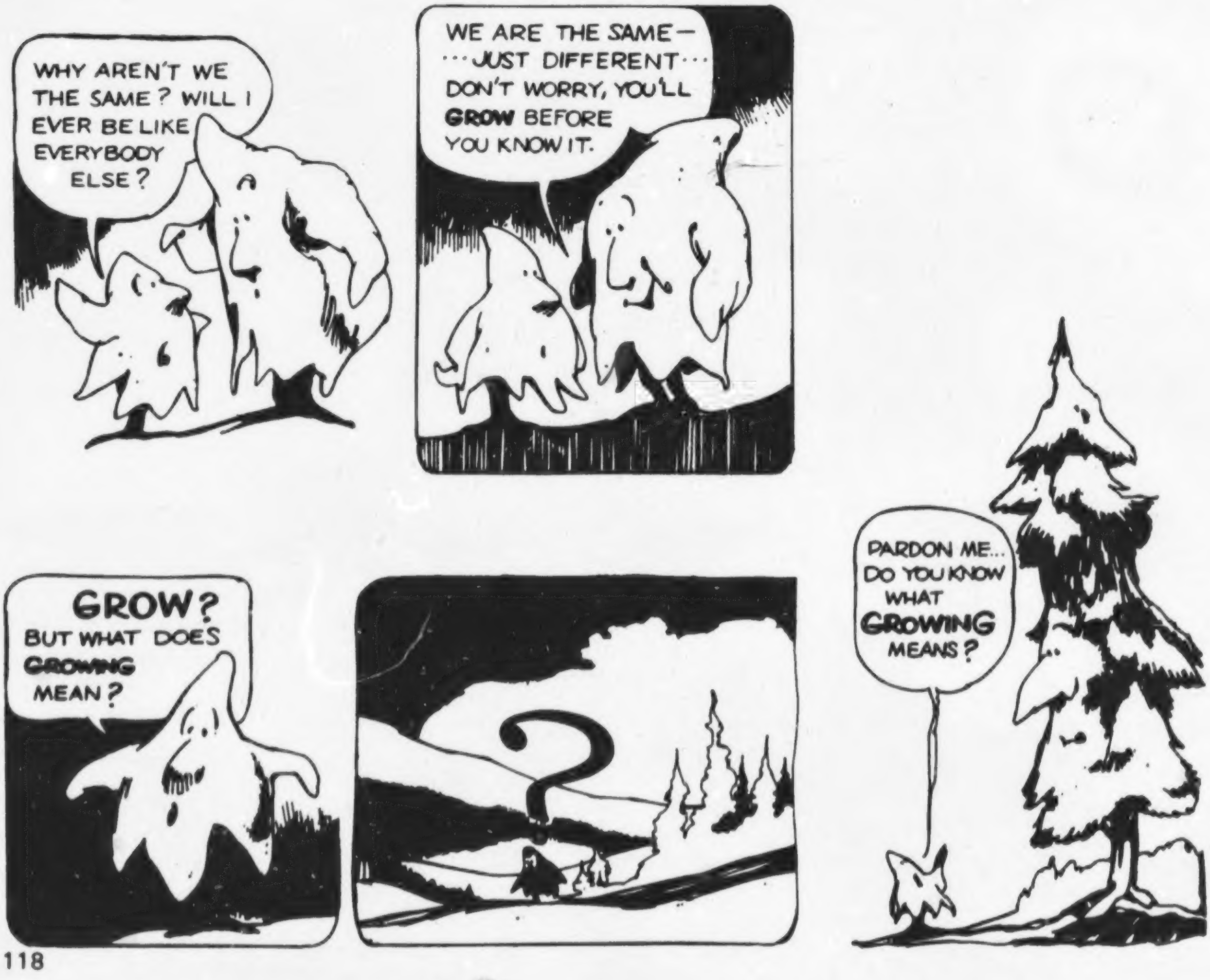
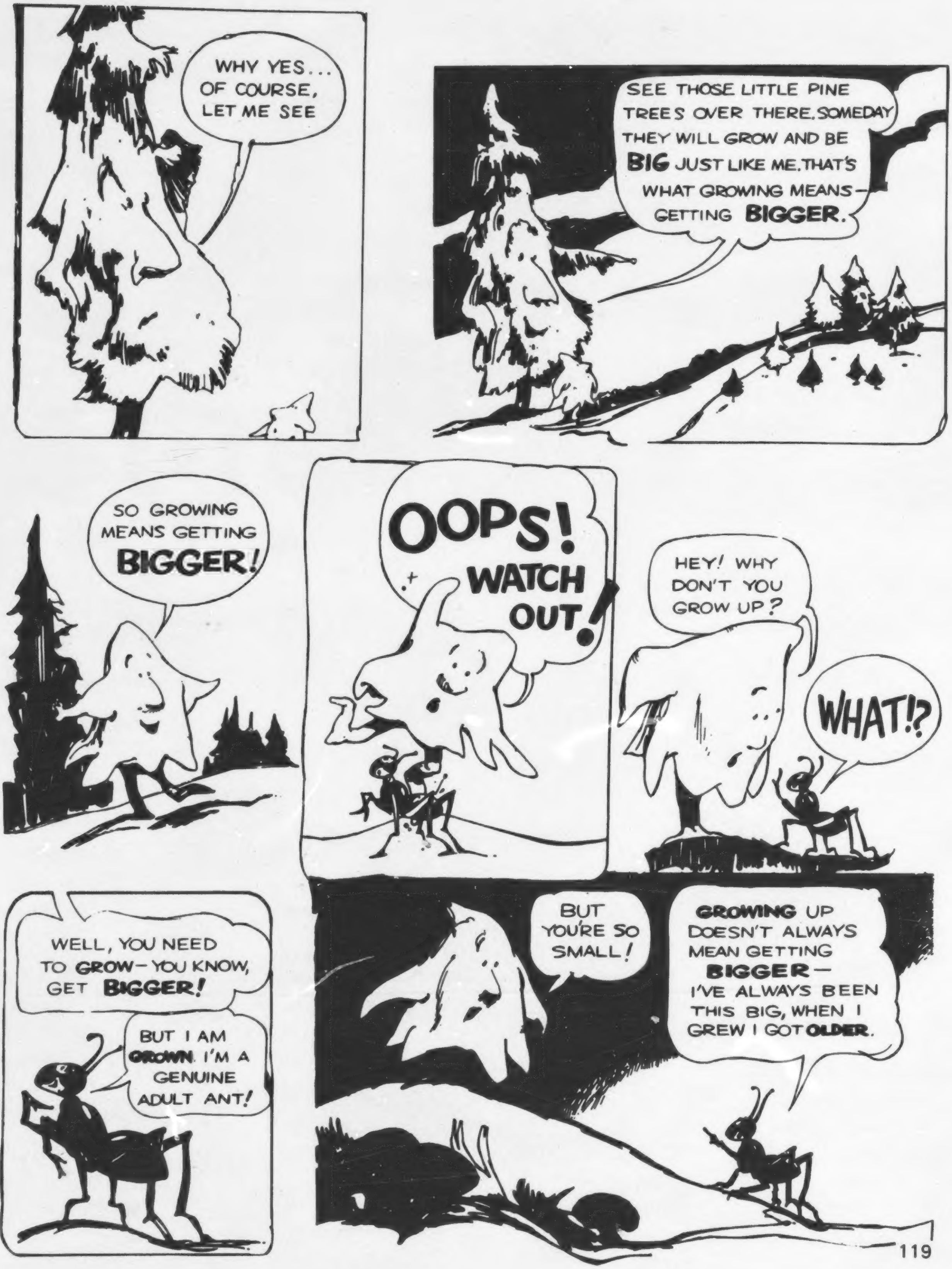
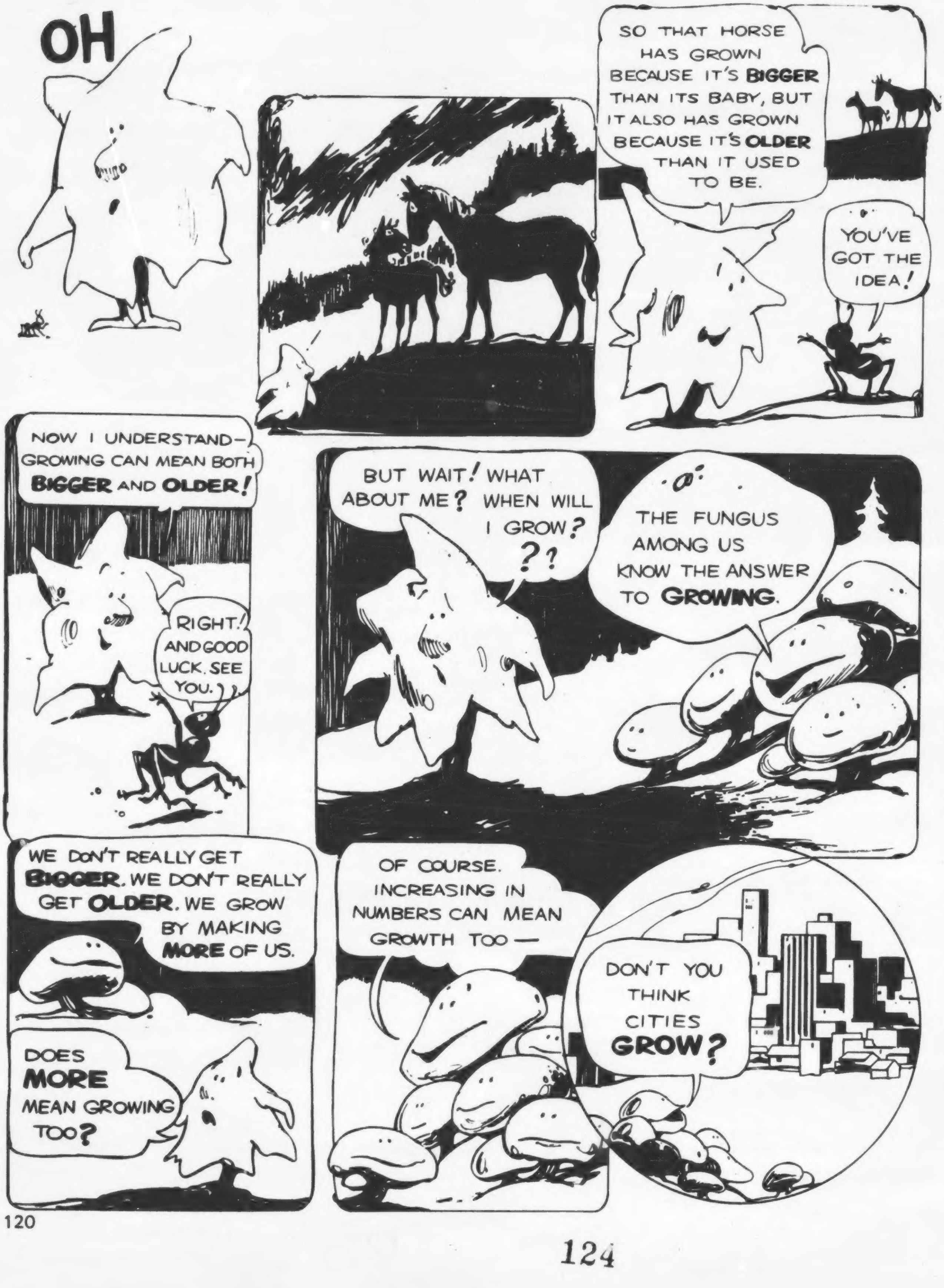
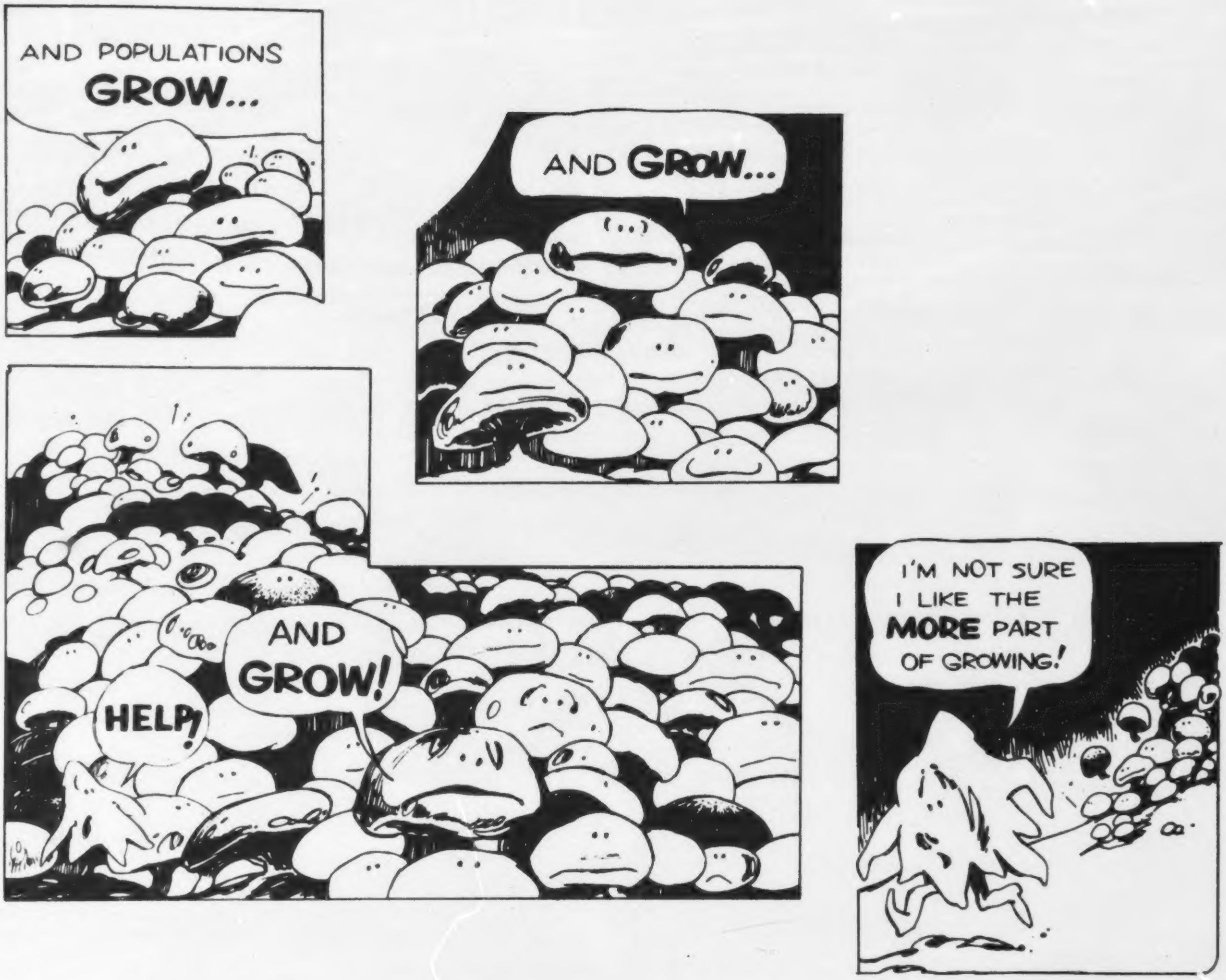
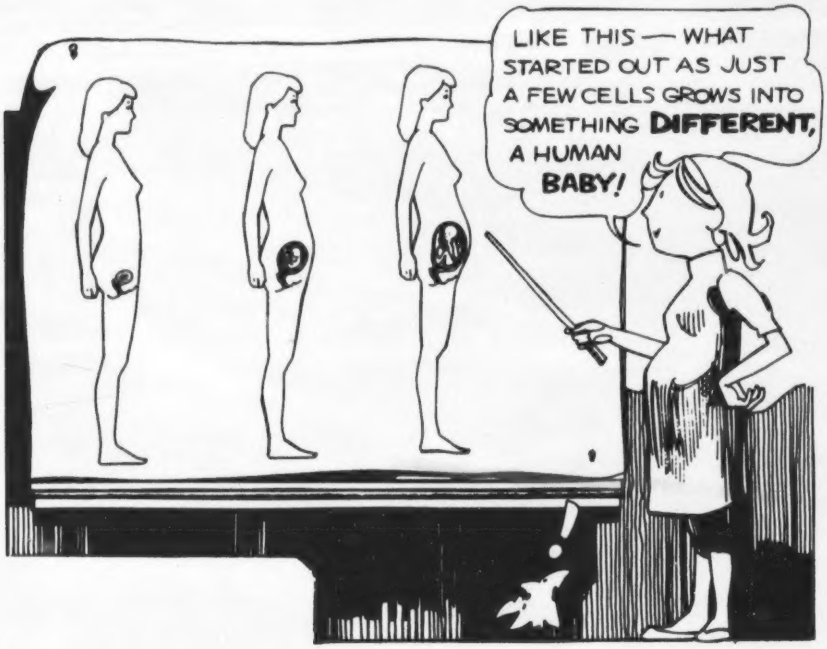

WHY AREN'T WE THE SAME? WILL I EVER BE LIKE EVERYBODY ELSE?
WE ARE THE SAME— ···JUST DIFFERENT··· DON'T WORRY, YOU'LL GROW BEFORE YOU KNOW IT.
GROW? BUT WHAT DOES GROWING MEAN?
?
PARDON ME... DO YOU KNOW WHAT GROWING MEANS?

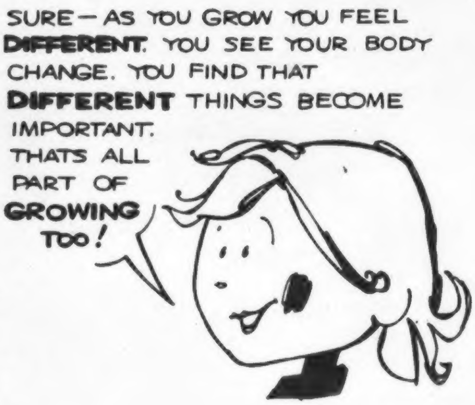

WHY YES... OF COURSE, LET ME SEE
SEE THOSE LITTLE PINE TREES OVER THERE. SOMEDAY THEY WILL GROW AND BE BIG JUST LIKE ME. THAT'S WHAT GROWING MEANS—GETTING BIGGER.
SO GROWING MEANS GETTING BIGGER!
OOPS! WATCH OUT!
HEY! WHY DON'T YOU GROW UP?
WHAT!?
WELL, YOU NEED TO GROW—YOU KNOW, GET BIGGER!
BUT I AM GROWN. I'M A GENUINE ADULT ANT!
BUT YOU'RE SO SMALL!
GROWING UP DOESN'T ALWAYS MEAN GETTING BIGGER—I'VE ALWAYS BEEN THIS BIG, WHEN I GREW I GOT OLDER.


OH
SO THAT HORSE HAS GROWN BECAUSE IT'S **BIGGER** THAN ITS BABY, BUT IT ALSO HAS GROWN BECAUSE IT'S **OLDER** THAN IT USED TO BE.
YOU'VE GOT THE IDEA!
NOW I UNDERSTAND– GROWING CAN MEAN BOTH **BIGGER** AND **OLDER**!
RIGHT! AND GOOD LUCK. SEE YOU.
BUT WAIT! WHAT ABOUT ME? WHEN WILL I GROW? ??
THE FUNGUS AMONG US KNOW THE ANSWER TO **GROWING**.
WE DON'T REALLY GET **BIGGER**. WE DON'T REALLY GET **OLDER**. WE GROW BY MAKING **MORE** OF US.
DOES **MORE** MEAN GROWING TOO?
OF COURSE. INCREASING IN NUMBERS CAN MEAN GROWTH TOO —
DON'T YOU THINK CITIES **GROW**?

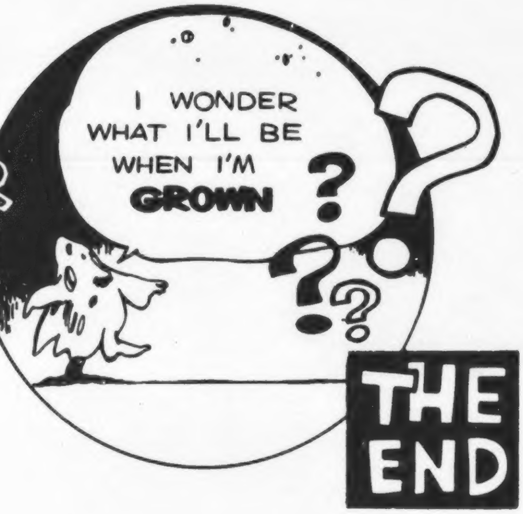

AND POPULATIONS GROW...
AND GROW...
HELP!
AND GROW!
I'M NOT SURE I LIKE THE MORE PART OF GROWING!
HEY! WHAT KIND OF GROWING ARE YOU?
I'M GROWING BIGGER!
YES — I CAN SEE THAT.
I'M GROWING OLDER!
YOU MEAN YOU'RE NOT A LITTLE KID ANYMORE.
AND I'M GROWING MORE TOO!
WHAT?
YES I'M GROWING ANOTHER PERSON RIGHT HERE.
BUT HOW?


LIKE THIS — WHAT STARTED OUT AS JUST A FEW CELLS GROWS INTO SOMETHING **DIFFERENT**, A HUMAN **BABY**!

GROWING **DIFFERENT**!? YOU MEAN TO TELL ME **DIFFERENT** IS A PART OF GROWING TOO!?


SURE — AS YOU GROW YOU FEEL **DIFFERENT**. YOU SEE YOUR BODY CHANGE. YOU FIND THAT **DIFFERENT** THINGS BECOME IMPORTANT. THATS ALL PART OF **GROWING** TOO!

WOW!
BIGGER
OLDER
MORE
DIFFERENT
?


I WONDER WHAT I'LL BE WHEN I'M **GROWN** ?
THE END

Going Further

1. Look at the living things around you. Look at the things that are not living. List the different kinds of growing that you can find in your environment.
2. Think about three age groups of people that you know. Talk to three people in each age group. Ask each person how he or she has changed or is different from the way they were three or five years ago. When you have all your results, think about how different people change over time.

Self Quiz

1. Four ways of growing are:
2. Name two ways you are growing. Give examples of your answer.

SECTION V
ENVIRONMENT

YOUR ENVIRONMENT INCLUDES YOUR FAMILY, FRIENDS, COMMUNITY, WORK, AND THE NATURAL WORLD.

HOW DOES YOUR ENVIRONMENT AFFECT YOU?

ACTIVITY 21
WHAT IS AN ENVIRONMENT?

You've probably heard the word "environment." What do you think of when you hear it? Do you think other people might think of different things when they hear "environment"? In this activity, you can find out about some different kinds of environment.

Directions

1. Look up the word "environment" in a dictionary. Read the definition. Using your own words, write the definition of environment.

2. Look around your classroom. List five nonliving things that are part of your classroom environment.

   List five living things that are part of your classroom environment.

3. Now try to think of ten living and nonliving things that are part of your home environment. List these things, or draw pictures of them.

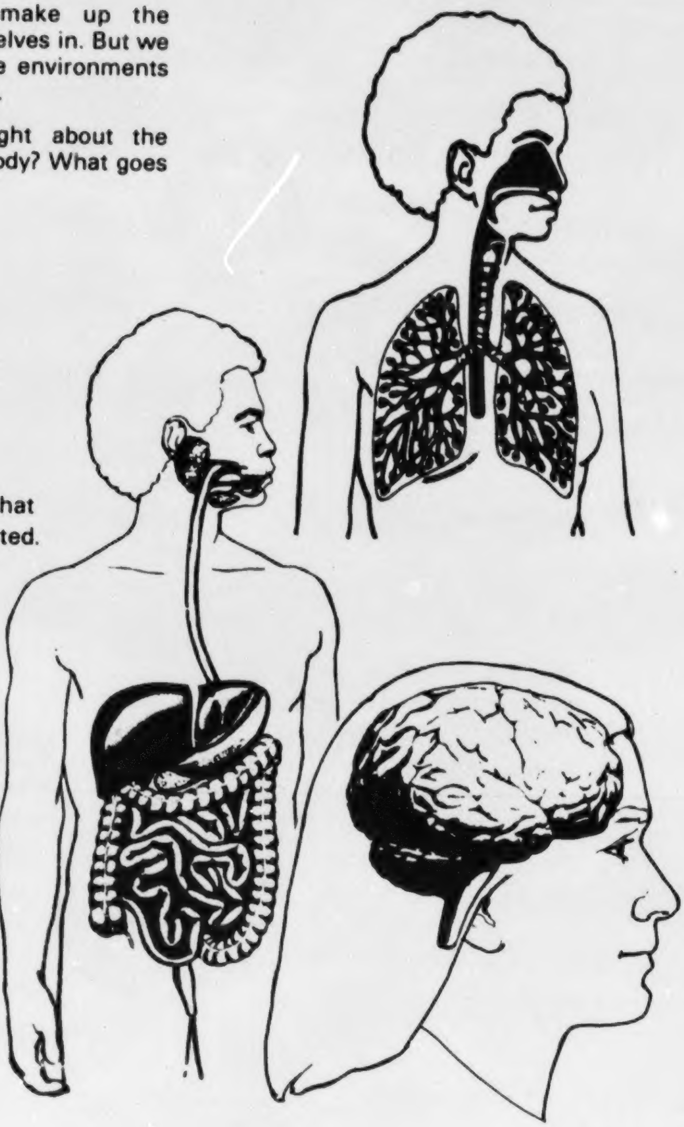
4. A city or town is one kind of environment. Name five things that might be part of a city environment.

5. If you drive out of the town along a country road, you will be in another kind of environment. Name five things that might be part of a country environment.

6. Many different things make up the environments we find ourselves in. But we have talked about only the environments that are outside our bodies.

   Have you ever thought about the environment *inside* your body? What goes on inside?

   List ten parts of your body that are doing the things you listed.



Questions for Discussion

Answer these questions as a class. Write your answers in the spaces provided.

1. Did all the students in your class list the same things for each environment?
2. When you are in a certain environment, are you a part of it?

   Explain your answer.

3. Give examples of some things that make up the environment inside your body.

4. Do both living and nonliving things make up an environment?

   Discuss the environments you might be in and the environment that is inside you.

5. If you could change two things that harm your environment, what would you change, and how?

6. Do you ever harm your environment?

   How?

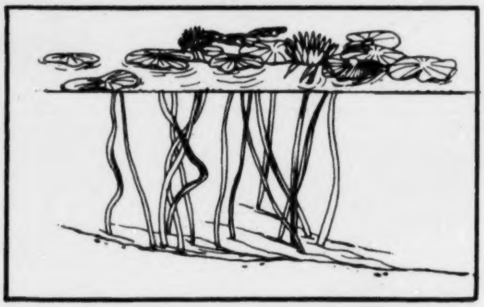
Going Further

1. The teacher will read one or two short sections. Try to imagine, then describe the environments.
2. Collect pictures of different types of environments from magazines or old posters. Use your pictures to make a collage.
3. Collect pictures of animals and plants that live in different environments. Think about how these plants and animals fit their special surroundings. Describe two different environments and the kinds of living things found in each.
4. Create an environment, inside a container, for a "something" (living or nonliving) that needs an area no larger than 30 cm x 30 cm. Bring the object in its environment to show the class. Be sure the object can't get out of the container. Describe the object's inside environment and its outside environment. Remember your "something" can be fiction or real.

Self Quiz

1. In your own words, write the definition of environment. Include an example of an environment.

Activity 22
WHAT IS ADAPTATION?



Can you tell what the living things in these pictures have in common? Look at each picture carefully. Where does each plant or animal live? Do they have any special things that make it easier for them to live in their environment?

Scientists call the special way a plant or animal fits into its environment an adaptation. For example, a monkey's tail, a turtle's shell, and a water lily's long roots and wide leaves are adaptations to unique environments.

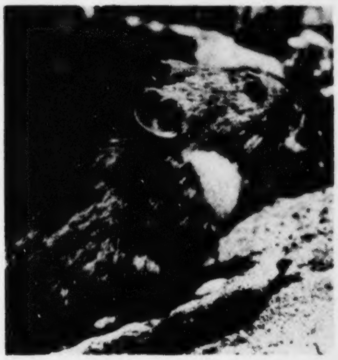
Can you think of an adaptation that you have? In this activity, you will have a chance to think about special adaptations. These adaptations allow plants and animals to live in their environments.

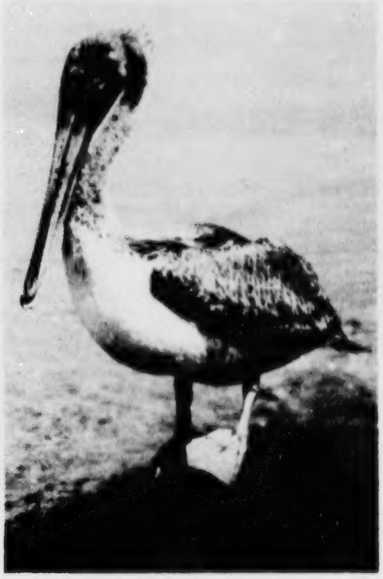
Materials

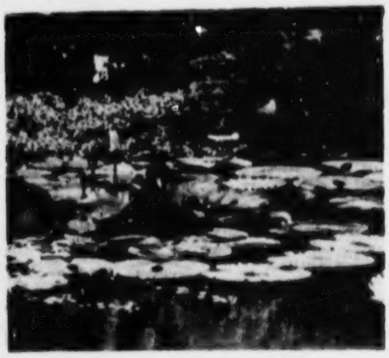
- Glue
- Paper clips
- Construction paper
- Toothpicks
- Tempera paint (white, black, green)
- String
- Scissors
- Masking tape
- Pencil
- Paper
- Stapler
- Assortment of "odds and ends"

Directions (Part I)

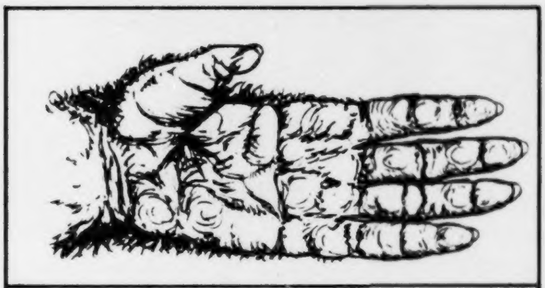
1. Look at each of these pictures. Look at the special ways each living thing is *adapted* to its environment. Adapted means the special way something fits into its environment. List the *adaptation* under each picture.

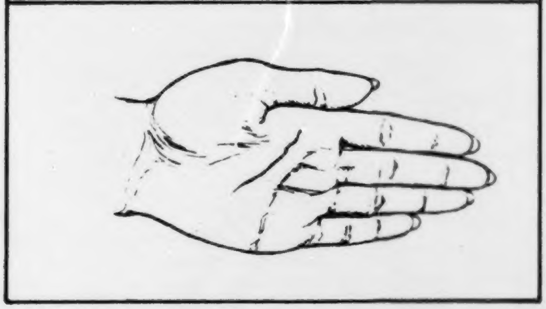




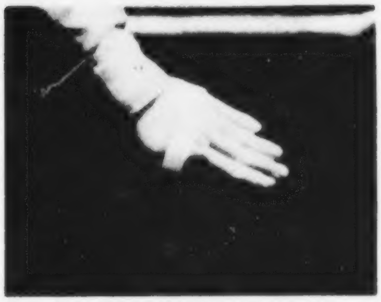


2. Look at these two pictures. How well do you think each hand could pick up a paper clip? Write your answer next to each picture.





3. Ask someone to tape the fingers of both your hands as shown here. Try doing the following tasks. Record your results in the chart.



TASK	EASY	DIFFICULT	VERY DIFFICULT
Pick up two paper clips			
Write your name			
Drink water from a glass			
Tie a shoe			
Turn a door handle			

Directions (Part II)

1. Think about adaptations in plants and animals that you know.
2. Think about an imaginary plant or animal. Imagine how it would fit into a certain environment. You can decide what its environment is.
3. Use the materials your teacher will give you to create an imaginary living thing. Give it special adaptations.
4. Describe your living thing. Tell how it fits into its environment. List its special adaptations. Tell how its ancestors may have looked, what adaptations they did not have, and the reasons the present adaptations may have come about. Do you think your living thing will pass these adaptations on to its offspring? How?
5. What adaptations would be necessary to make you a flying or water-breathing animal?
6. Tell the class or your group how your living thing is especially adapted to its environment.
7. Give your living thing to your teacher. Also return the materials you did not use. Then answer the Questions for Discussion on the next page.

Questions for Discussion

Write your answers to these questions. Discuss your answers with the class.

1. Tell, in your own words, the meaning of "adaptation."

2. How is your hand adapted to writing while an ape's hand is not?

3. What is there about an ape's hand that would make writing difficult?

4. List five living things in your environment. Name one adaptation each of these living things has.

Going Further

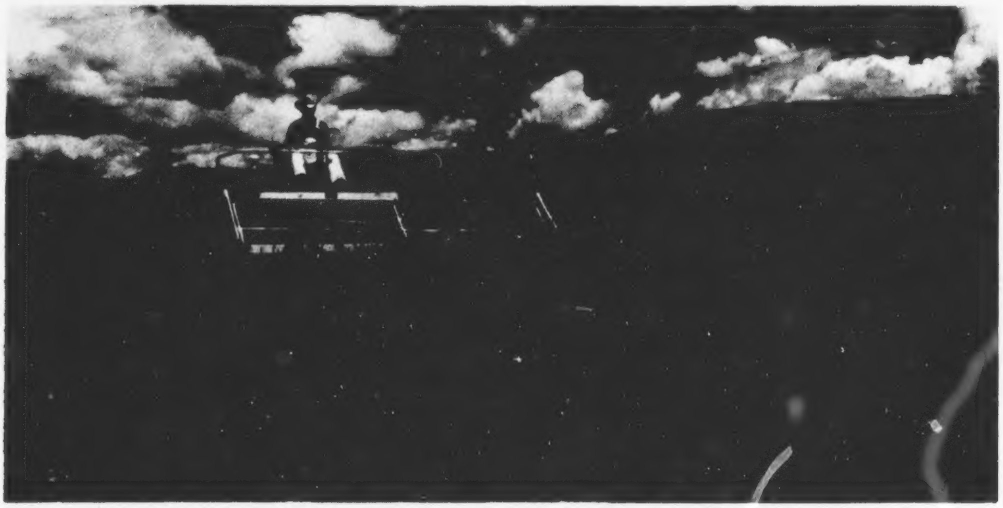
1. Look at pictures of different kinds of plants and animals. Tell how they are adapted to their environments.
2. Look at a living plant or animal. Tell how it is adapted to its environment.

Self Quiz

1. Tell how your creation is especially adapted to its environment. Give your creation to your teacher.

Activity 23
TIME MACHINE

People adapt to their environments in different ways. You talked about biological adaptations in Activity 22, when you discussed how ape hands and human hands differ. You talked about adaptations that happen to a group of living things over a long period of time. Examples of biological adaptations are the upright walk and speech of humans, the white color of polar bears, the venom in some snakes, the streamlined shape of a dolphin, and trees losing their leaves in the fall. In these kinds of adaptations, an individual cannot decide to change suddenly to fit the environment. The changes happen through many generations. They happen in small stages.



In this activity, you will examine another type of adaptation—social adaptation. Humans can change their environment. For example, we can put on warm clothing when the weather is cold; we have changed our immediate environment. We have adapted to that cold temperature by changing our clothing. This is not a biological adaptation; it is a social adaptation. In this activity, you will be talking about social adaptations.

Materials

Role cards
Costumes and props

Directions

1. In this activity, you will play the part of a person who has lived in the past or one who is living in the present. You will act out how that person is adapted to her or his environment. Work in groups of five students to play "Time Machine."
2. Your teacher will give your team five role cards. Read the cards and choose which character you would like to play. With your team, make up a five-minute skit that you can present to your class. Include the jobs listed on the cards as part of your skit.
3. When it is your turn, act out your skit. Use the costumes and props that your teacher has provided. Talk and use the props as if you were living at the time described on your role cards. Use only the props for your time period. Don't use modern tools if you are supposed to be living in the past. However, you can use tools that were used before the time in which you are supposed to be living. For example, if you are playing the part of someone who lived in pioneer days, you can use hoes. You also can use plows pulled by horses but not by tractors.
4. When each group has acted out a skit, give the role cards to your teacher. Then answer the Questions for Discussion.

Questions for Discussion

Discuss the following questions with your classmates. Record your answer in the space provided.

1. How did people in each of the times obtain food?

   Prehistoric

   Pioneer days

   Early 1900s

   Modern times

2. How did people in each time heat their homes?

   Prehistoric

   Pioneer days

   Early 1900s

   Modern times

3. How did people in each time find valuable items for trade?

   Prehistoric

   Pioneer days

   Early 1900s

   Modern times

4. Which has changed more over the last 500 years, the basic appearance of humans or the environment?

   Explain your answer.

5. Other organisms—plants and animals—adapt to their environments. What is different about the way humans adapt as compared to other animals and plants?

6. Which do you think changes faster: the genes that organisms of the same type share or the environment?

   Explain your answer.

Going Further

1. Read about the lives of American Indians in the encyclopedia or in books about Indians. Think about how they adapted themselves to their environment in the past. Write a paragraph or story about an imaginary Indian family. Show how they lived in their environment. Do some Indians live this way today?
2. Look in the encyclopedia or in newspapers for articles about different people who are living today. Read about people such as Australian aborigines, African Masai, modern urban people, present-day people living in small towns. Compare how different people adapt to their environments.
3. Biologists have evidence that the dinosaurs became extinct about 20 million years ago. The dinosaurs must have become extinct because they could not adapt to some change in their environment. Sharks have not changed their basic form for millions of years and have survived. Use your science books or encyclopedia to find out more about why dinosaurs died out and why sharks have survived in the same form for so many years.

Self Quiz

1. Tell three ways you have adapted to your environment.

2. Name three things that you do now that you might have done differently during prehistoric time.

3. Name three examples of adaptation. Use any plants or animals as your examples.

Activity 24
STOMACH ACHES AND MILK

Every cell in the human body has over 100,000 genes. Each gene provides a specific piece of information that is necessary for the growth and health of the body. In this activity, you will read about one of the genes that helps our bodies digest milk.

Directions

1. Look at the transparencies about chromosomes, genes, and milk that your teacher will show you.
2. Read the following story about genes and milk digestion. Then answer the Questions for Discussion.

CAN YOU DRINK MILK?

Everyone knows that babies need milk to grow. But many older children and adults get stomach cramps after drinking one or two glasses of milk. If babies don't get sick from drinking milk, why do adults?

Milk contains many important nutrients. One of these is lactose, a form of sugar.

Milk contains many important nutrients. One of these is lactose, a form of sugar. Lactose is too big to be absorbed through the walls of the small intestine. Lactose must be broken down into smaller pieces that the body can use.

All baby mammals (humans, cats, cows, whales, and others) can break down lactose in milk. Their bodies make a certain enzyme that can split lactose. Since their mother's milk is the only source of food for most of these babies, this enzyme is very important.

Most adult mammals lose the ability to make this enzyme. Most humans stop making it by the time they start school. Without the enzyme, they cannot digest the lactose in milk. People whose bodies do not make this enzyme often dislike milk. Drinking only half a glass of milk may give them stomach cramps, gas, and even diarrhea.

OPEN →
MILK
PASTEURIZED
HOMOGENIZED
MILK
ONE HALF GALLON
PASTEURIZED
HOMOGENIZED
MILK

88% Water

5% Sugar (lactose)

3% Protein

3% Fats

1% Minerals (calcium, phosphorus, etc.

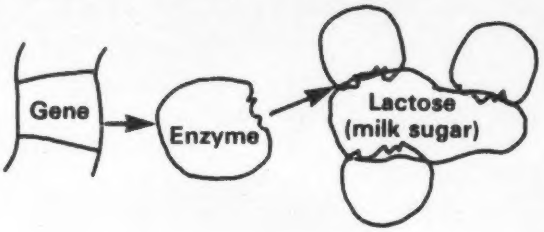
1% vitamins (A, D, E, K, etc.)

Over 30 million American adults and most of the adults in the rest of the world do not make this special enzyme. Some of these people include the Australian aboriginals, Chinese, Japanese, Filipinos, Eskimos, American Indians, American Blacks, and most Africans.

Many people of northern European heritage continue to make the enzyme throughout their lives. The ability to continue making the enzyme is controlled by a dominant gene.

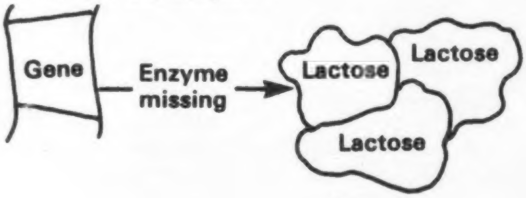
If one or two dominant genes are present, the individual continues to make the enzyme and can drink milk without problems. With two recessive genes, the adult does not make the enzyme, and drinking milk products becomes painful.

In people who make the enzyme



enzyme breaks down lactose.

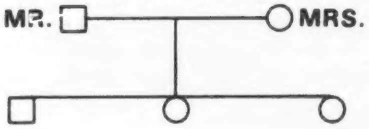
In people who do not make the enzyme



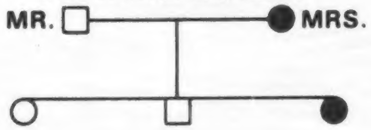
lactose is not digested.

Look at the three pedigrees shown here. In which families would drinking milk be a problem?

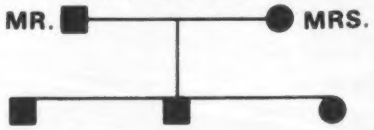
THE CHANGS



THE WHITEFEATHERS



THE SMITHS



■ can digest milk

□ cannot digest milk

Questions for Discussion

Write your answers to these questions. Then discuss your answers with the class.

1. What is a baby's main source of food?
2. What would happen if a baby couldn't digest milk?

Going Further

1. Plan a diet for someone who cannot digest lactose. What milk products can they eat and drink? The local dairy association or a hospital dietician may have the information you need. Consider the nutrients milk has and the body needs in planning the milk substitutes.
2. Another condition that occurs because of the lack of an enzyme is PKU. However, this condition is much more serious, because it can result in serious mental retardation. All babies born in hospitals in most states are tested soon after birth for the absence of the enzyme, phenylalanine. If the enzyme is missing, the child is put on a diet to restrict the intake of phenylalanine. If the child does not receive the diet, his/her brain may be damaged. The child must remain on this diet from shortly after birth until he or she is seven to ten years old.

   Try to imagine the problems or pressures a school-age child encounters who is on the diet and cannot eat the foods other children are eating.

   Discuss the difficulty you would encounter, as the parent of a PKU child, in trying to persuade your young child never to eat the forbidden foods (such as regular cake and cookies, beans, peas, peanuts, cheese, regular milk, hamburgers, bacon, hot dogs, and so on.)

   It is also possible that a woman who has PKU, but is no longer on the diet, could have a retarded child. If she is no longer on the diet, she could build up high levels of phenylalanine. This could be passed to her chld. The woman may have to go back on the diet during her pregnancy to avoid building up phenylalanine which could harm the child she is carrying.

Self Quiz

1. Explain how babies are adapted to their main food source.

2. Explain why it is less important for adults to be able to digest milk than for babies.

Activity 25

CANCER AND HEREDITY

About one out of every four people will develop cancer sometime during her or his lifetime. For some people, the cancer will be detected early; they will live. For others, the cancer will spread, undetected, until it causes death. Cancer is the second most common cause of death in the United States.

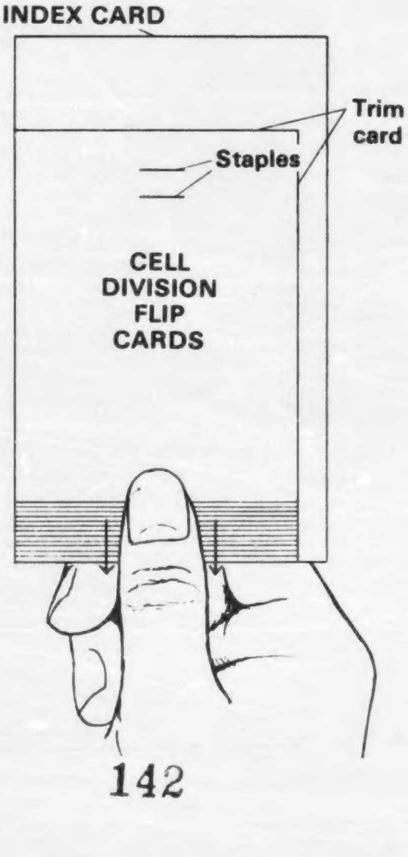
What is cancer? What do we know about its causes? In this activity, you will find out some basic information about cancer.

Materials

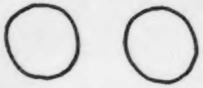
Index cards (3" x 5")
Scissors
Stapler

Directions

1. Before you can begin to understand cancer, you need to know about cell division. Cut apart the Cell Division Flip Cards that are printed on pages 141 and 143.
2. Read the descriptions on the Cell Division Flip Cards. Put the cards in order to show the sequence of cell division.
3. If your cards are in the proper order, the letters in the lower left corners will spell CHROMOSOMES SPLIT.
4. Assemble a flip booklet, as shown here.
5. To see how cell division works, release the edges of your flip booklet, one by one.
6. Look at the pictures projected by your teacher. The first one shows cells dividing normally. The second one shows cells in which division is out of control. These cells are dividing much too quickly. We call this condition cancer.

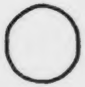


In some cells...



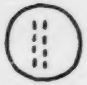
O

Each cell takes in materials from the environment. It grows larger. The drawing below represents a living cell.



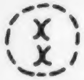
H

Inside cells are chromosomes. They usually cannot be seen, but they are still there.



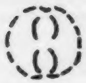
R

When a cell grows to a certain size, it starts to split. This is when chromosomes first appear. They are already doubled.



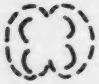
O

Early in cell division, the doubled chromosomes split.



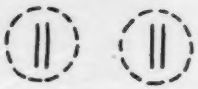
M

Then the entire cell begins to divide in half.



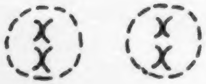
O

When the cell divides completely, each half has its own set of chromosomes.



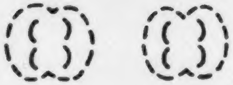
S

...cell division is complete...



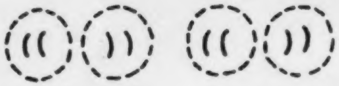
M

...in only...



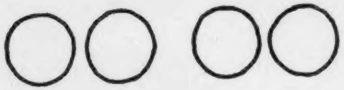
E

...15 minutes...



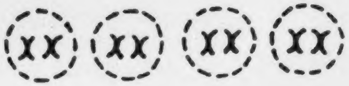
S

In other cells...



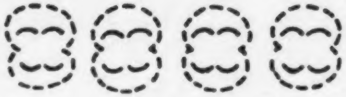
S

...division takes...



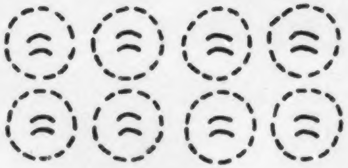
P

...as long as...



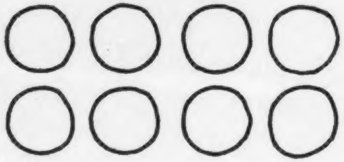
L

...several hours.



I

Cell division is a continuous process throughout the normal humban body.



T

CELL
DIVISION
FLIP
CARDS

C

7. Read the story about cancer that begins below. Refer to the List of Cancer-Related Terms on page 146 for definitions of the words in italics.

8. Complete the Cancer Crossword. Compare your answers with those of other students.

Questions for Discussion

Discuss these questions with the class. Write your answers in the spaces provided.

1. What happens during cell division?

2. How are cell division and cancer related?

3. What are some ideas about the causes of cancer?

4. Why is early detection of cancer important?

5. What are some early signs of cancer?
   What should you do if one appears?

6. What do you think causes cancer?

CANCER

The word *cancer* refers to a class of diseases that are the result of uncontrolled cell division. In cancer cells, division is out of control. These abnormal cells invade the healthy tissue around them. If they are not stopped, they can spread to the bloodstream and to other parts of the body.

Abnormal cells can group to form a *tumor,* or lump. Tumors can be *benign* or *malignant.* Benign tumors can grow but do not spread. Often they can be removed easily. Tumors that are malignant invade other parts of the body. Cells in bone marrow make blood cells. Cancer of these cells is called *leukemia.*

The tendency to develop some forms of cancer seems to be inherited. More than a hundred inherited conditions have been linked to the development of cancer. Some breast, lung, and skin cancers have shown patterns of inheritance.

Other forms of cancer may be the result of interactions between genes and environment. Many scientists suggest that something in the environment can change the structure of genes. Something causes genes to *mutate.* Some types of *mutations* may cause cells to divide abnormally. Cancer begins. Chemicals and other substances that seem to bring on cancer are called *carcinogens.* Cigarette smoke, X rays and other radiation, some drugs, certain viruses, and some chemicals are among the carcinogens that have been identified. Exactly how these substances cause cancer is not yet known.

Each year, over 675,000 new cases of cancer are reported in the United States alone. Survival rates depend a great deal on how quickly cancer cells are detected. If abnormal cells are still in one location, the tumor sometimes can be removed surgically or destroyed with controlled radiation. It is much more difficult to locate and destroy abnormal cells after they have spread.

Early warning signs of possible cancer include: a lump in the breast or elsewhere, unusual bleeding or discharge, a sore that doesn't heal, change in a wart or mole, change in bowel or bladder habits, hoarseness or cough, indigestion, and difficulty in swallowing. These also are signs of other health problems. Medical tests can show if they are cancer related.

Some scientists predict that, to prevent cancer, we will need to get rid of hazardous substances in our environment. Others suggest that hope for cancer control is in our understanding of genes and of processes that change gene structure. By learning more about cell division, we may one day be able to prevent cancer or eliminate its spread through healthy cells.

Going Further

1. Contact your local office of the American Cancer Society or the Leukemia Society of America for materials that give more information about cancer. Find out if someone there would talk to your class about cancer.
2. Find out about the major theories concerning the cause and treatment of cancer. Use the *Reader's Guide to Periodical Literature* to find articles on chemotherapy, radiation treatments, diet modifications, or interferon experiments.

LIST OF CANCER-RELATED TERMS

BENIGN (be-NINE) doing little or no harm; not malignant.

CANCER (KAN-ser) a class of diseases charaterized by uncontrolled cell division.

CARCINOGEN (kar-SIN-e-jen) a physical or chemical agent that induces cancer.

CARCINOMA (kar-si-NO-ma) cancer found in sheets of cells covering the body and lining all hollow body organs.

LEUKEMIA (loo-KEY-me-a) cancer in blood-forming cells of bone marrow, lymph glands, or spleen, characterized by an overproduction of white blood cells.

MALIGNANT (ma-LIG-nent) very dangerous; causing or likely to cause death; not benign.

MUTATE (MEW-tate) change; MUTATION, process by which a gene undergoes a structural change. Some mutations can lead to cancer.

SARCOMA (sar-KOE-ma) cancer in bone or connective tissues of the body; rarest form of cancer.

TUMOR (TOO-mer) a mass of tissue that grows from the cells of surrounding tissue; a lump. Not all tumors are cancer.

Self Quiz

1. Do the cancer crossword puzzle.

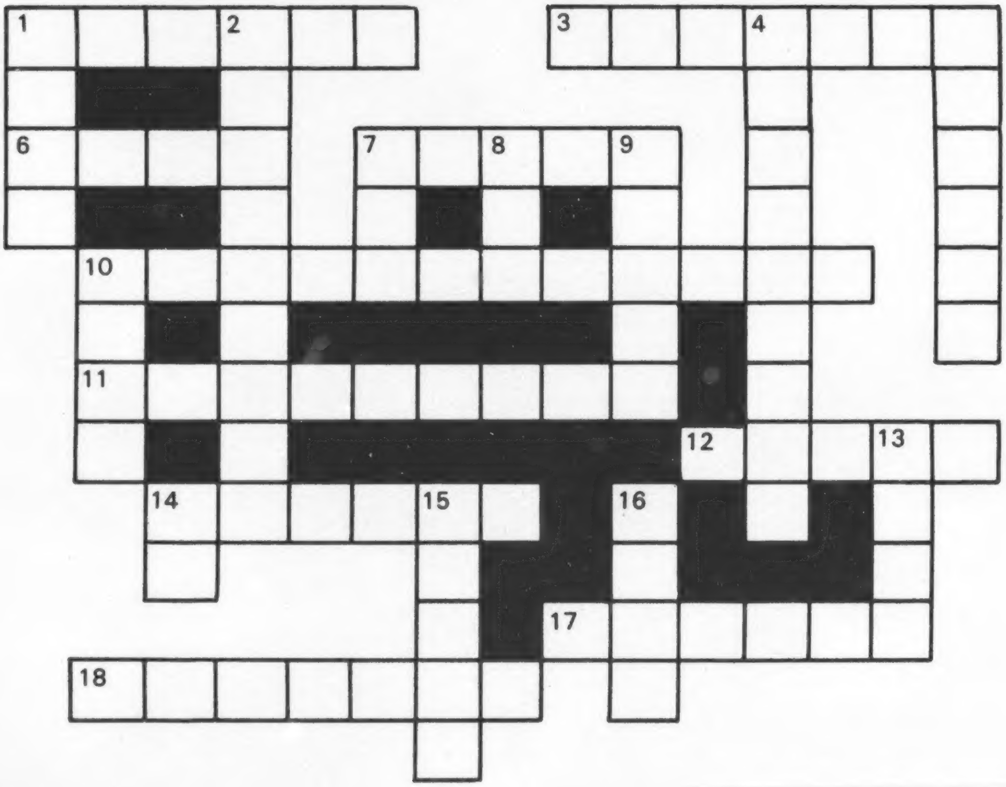
CANCER CROSSWORD

Across

1. The No. 2 killer in the U.S. today
3. A frequent site of cancer
6. A type of cancer that may be hereditary
7. A lump of cells
10. Your _____ may affect your chances of getting cancer.
11. A frequent site of cancer
12. No one _____ what causes cancer.
14. A tumor that does not spread is _____.
17. Frequent site of cancer in women
18. Cancer may be caused when something _____ a gene or genes.

Down

1. New cells are made by _____ division.
2. _____ smoking causes lung cancer in some people.
4. A cancerous tumor that spreads is _____.
5. If you have cancer, you are not in good _____.
7. Some people say _____ much of anything causes cancer.
8. The prostate gland is a frequent site of cancer in _____.
9. Your parents having cancer may _____ your chances of getting it.
10. Too much sunshine can cause _____ cancer in some people.
13. A change in a mole or _____ could signal cancer.
14. Cancer may _____ due to gene/environment interaction.
15. The basis for cancer may be in the _____.
16. A _____ that won't heal may signal cancer.



GENES AND SURROUNDINGS

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ISBN 0-8403-3065-0